Gear	Era	Season	Area (km2)	% of Total Area	Habitat Type
Pelagic Trawl	1	Winter, Summer & Transition	408.93	53.1%	Sedimentary Shelf
			134.30	17.4%	Sedimentary Slope
			94.27	12.2%	Rocky Shelf
			45.61	5.9%	Sedimentary Ridge
			20.94	2.7%	Sedimentary Shelf Canyon Wall
			18.33	2.4%	Sedimentary Slope Canyon Wall
			17.71	2.3%	Rocky Ridge
			11.37	1.5%	Rocky Slope
			10.93	1.4%	Sedimentary Slope Canyon Floor
			3.69	0.5%	Rocky Slope Canyon Wall
			1.84	0.2%	Sedimentary Slope Landslide
			1.82	0.2%	Sedimentary Basin
			0.42	0.1%	Sedimentary Shelf Canyon Floor
			0.07	0.0%	Rocky Basin
			0.03	0.0%	Rocky Slope Landslide
Pelagic Trawl	2	Winter, Summer & Transition	267.47	61.4%	Sedimentary Shelf
			74.02	17.0%	Rocky Shelf
			39.95	9.2%	Sedimentary Slope
			20.94	4.8%	Sedimentary Shelf Canyon Wall
			18.33	4.2%	Sedimentary Slope Canyon Wall
			10.93	2.5%	Sedimentary Slope Canyon Floor
			3.69	0.8%	Rocky Slope Canyon Wall
			0.42	0.1%	Sedimentary Shelf Canyon Floor
			0.06	0.0%	Rocky Slope
Pink Shrimp Trawl	1	Summer	3250.07	84.3%	Sedimentary Shelf
			555.41	14.4%	Sedimentary Slope
			48.78	1.3%	Rocky Shelf
			1.05	0.0%	Rocky Slope
Pink Shrimp Trawl	2	Summer	3250.07	84.3%	Sedimentary Shelf
			555.41	14.4%	Sedimentary Slope
			48.78	1.3%	Rocky Shelf
			1.05	0.0%	Rocky Slope
Pink Shrimp Trawl	3	Summer	3250.07	84.3%	Sedimentary Shelf
			555.41	14.4%	Sedimentary Slope
			48.78	1.3%	Rocky Shelf
			1.05	0.0%	Rocky Slope

5. Conclusion

In December 2003 this paper was sent to members of the TRC and other interested parties involved in the EFH process for review. One comment was received during this review period and changes to the document are reflected in this final version. Additionally, this work was presented to the Groundfish Subcommittee of the Scientific and Statistical Committee (SSC) of the Pacific Fishery Management Council in February 2004 as part of their review of the analytic portions of the EIS for designating Groundfish Essential Fish Habitat (Ralston et al. 2004).

Based on this review process, this assessment provides sufficient data to continue with the EFH Impacts Model based on trawl logbook data stored in the PacFin Database. These data represent the most comprehensive spatial data for fishing effort on the West Coast (Ralston et al. 2004). In the future, NOAA Fisheries Vessel Monitoring Program will enable the refinement of trawl fishing effort. It is recognized that data gaps do exist most notably in the areas of fixed gear and recreational fishing effort. It is hoped that future data development efforts in these areas (i.e. additional focus group sessions) will provide information useful in subsequent enhancements of the EFH impacts model. Finally, this asessment highlights potential future research tracks on questions of intensity measures and effort / habitat relationships.

6. References

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Ralston, S., Dorn, M., Dalton, M., Berkeley, S., Jagielo, T., and Lai, H. 2004. "A Review of the Analytical Portions of the Environmental Impact Statement for Designating Groundfish Essential Fish Habitat; A Report of the SSC Groundfish Subcommittee." Exhibit C.6.c, Attachment 1, April 2004 Pacific Fishery Management Council Briefing Book.

Scholz, A. J. 2003. "Groundfish Fleet Restructuring Information and Analysis Project." Final Report and Technical Documentation. Pacific Marine Conservation Council / Ecotrust.

7. Acknowledgements

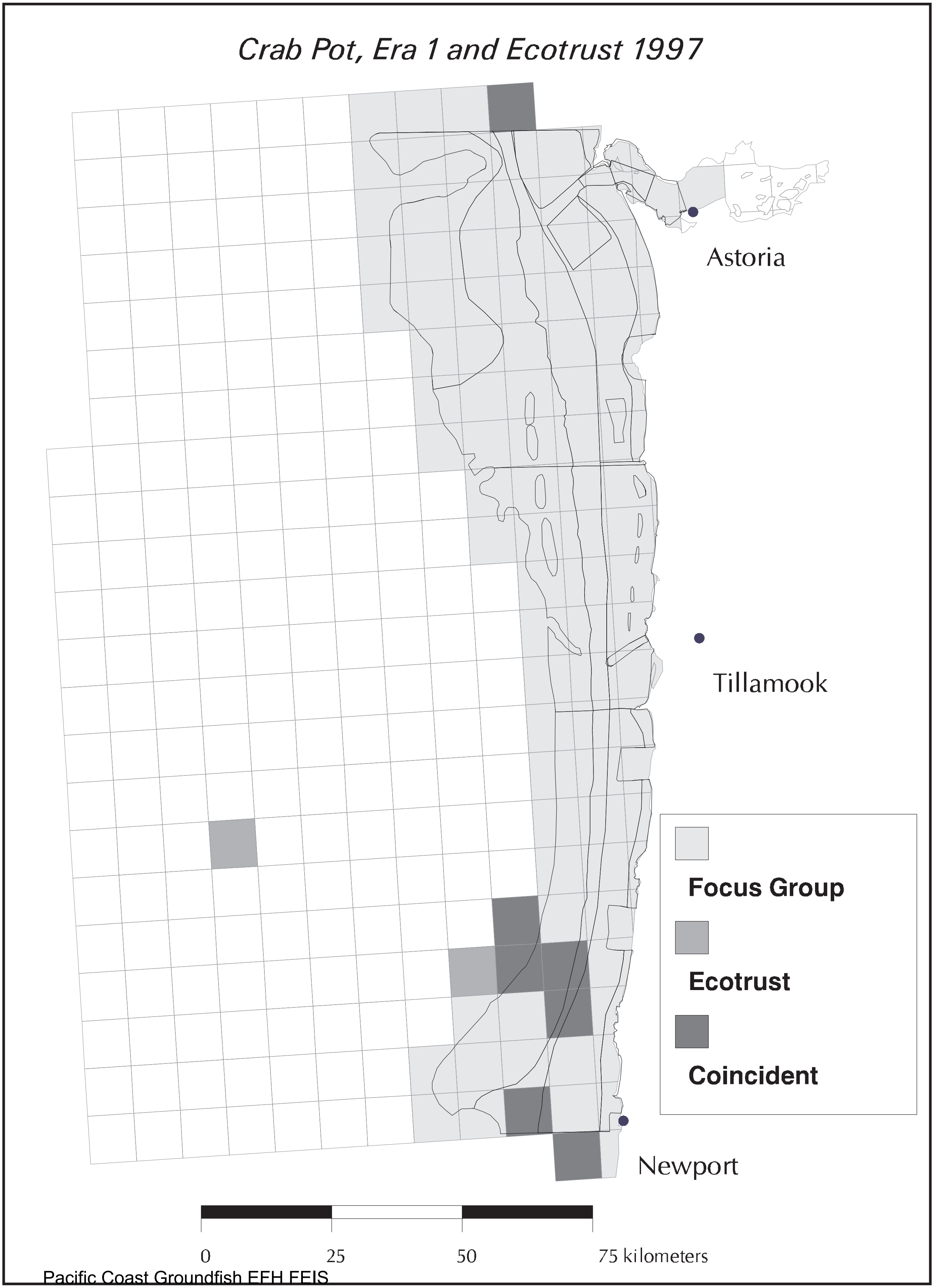
The authors would like to thank the following people and organizations for their contributions to this assessment: Bruce Thomas, TerraLogic GIS; Randy Fisher, Dave Colpo, Fran Recht, William Daspit, and Brad Stenberg, Pacific States Marine Fisheries Council; Scott McMullen, Oregon Fishermen's Cable Committee; Astrid Scholz, EcoTrust; Members of the EFH Technical Review Committee; Members of the Scientific and Statistical Committee.

Financial support for this project was provided by National Marine Fisheries Service Northwest Region Office and Pacific States Marine Fisheries Commission.

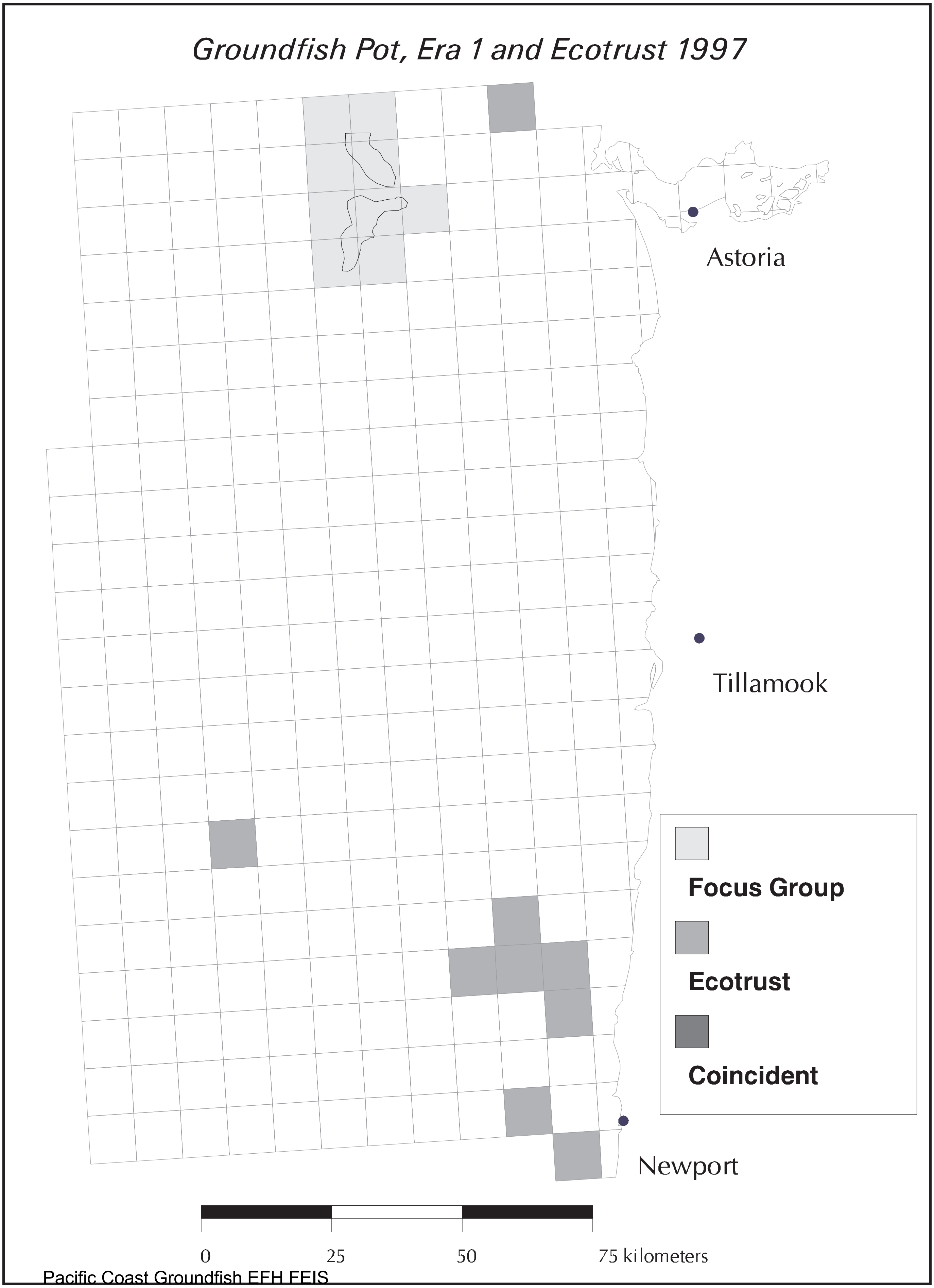
Appendix A

Focus Group and Ecotrust Comparison Maps

Coincidence of Focus Group and Ecotrust Effort

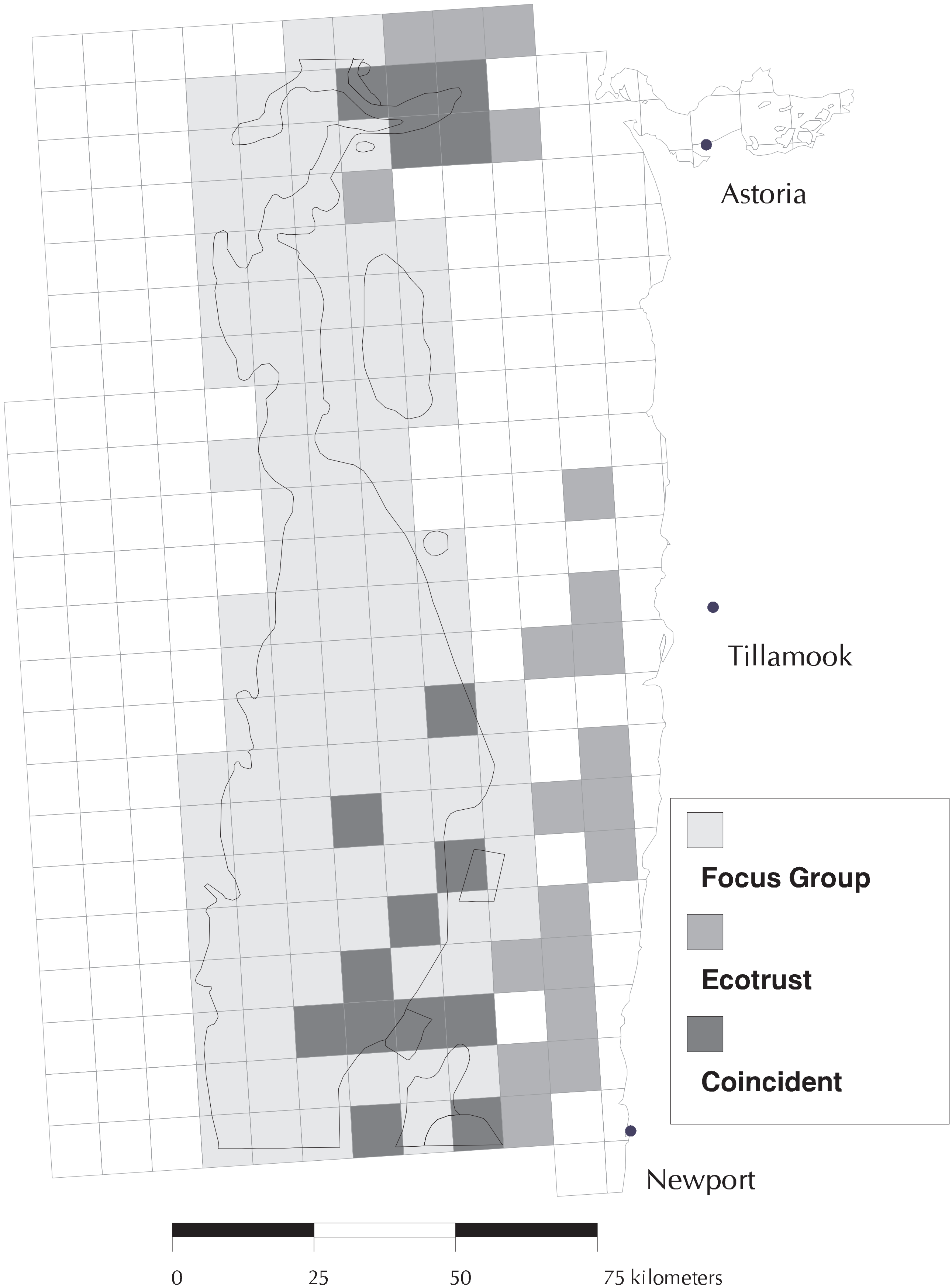


Coincidence of Focus Group and Ecotrust Effort



Coincidence of Focus Group and Ecotrust Effort

Longline, Era 1 and Ecotrust 1997



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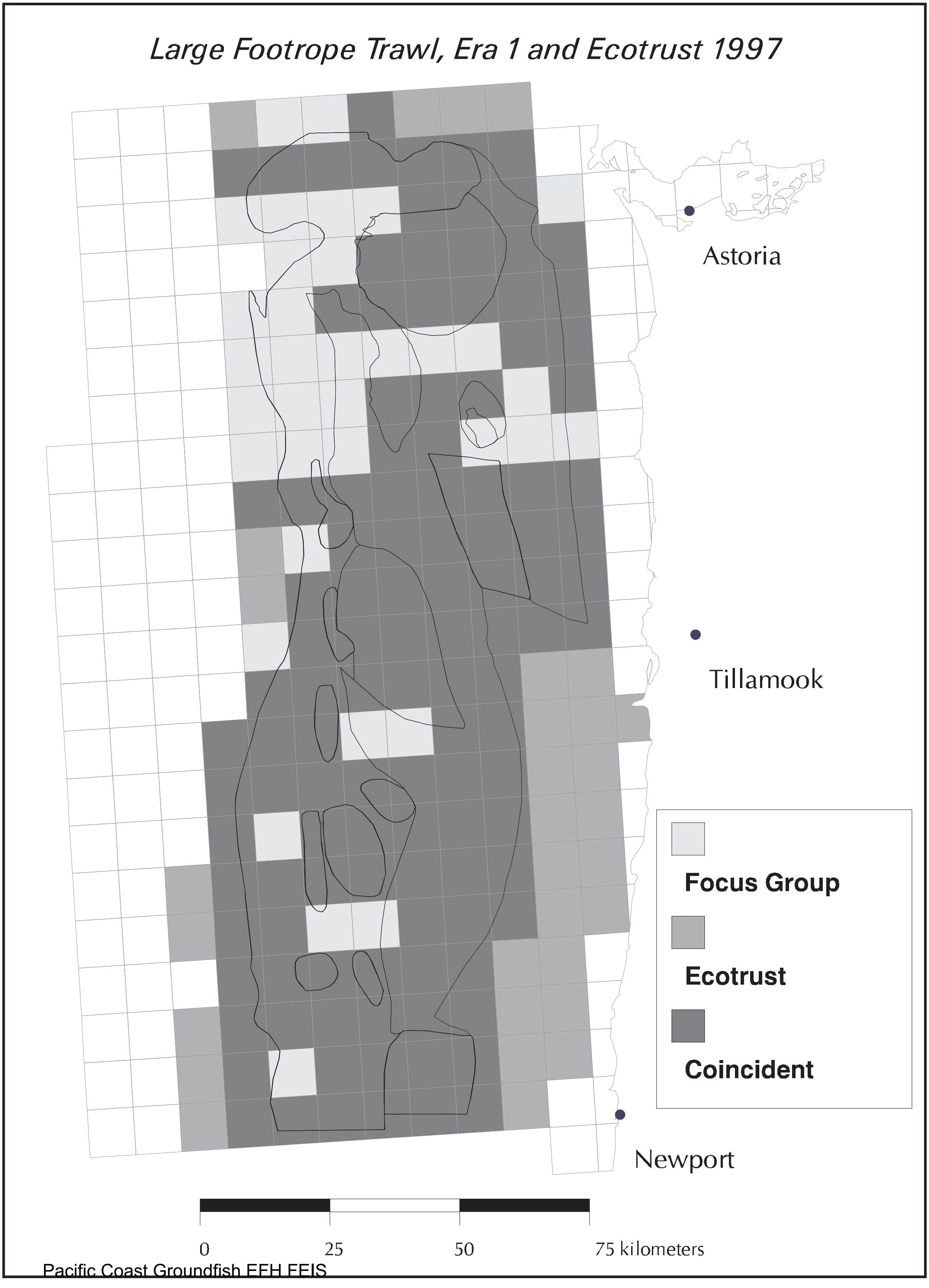
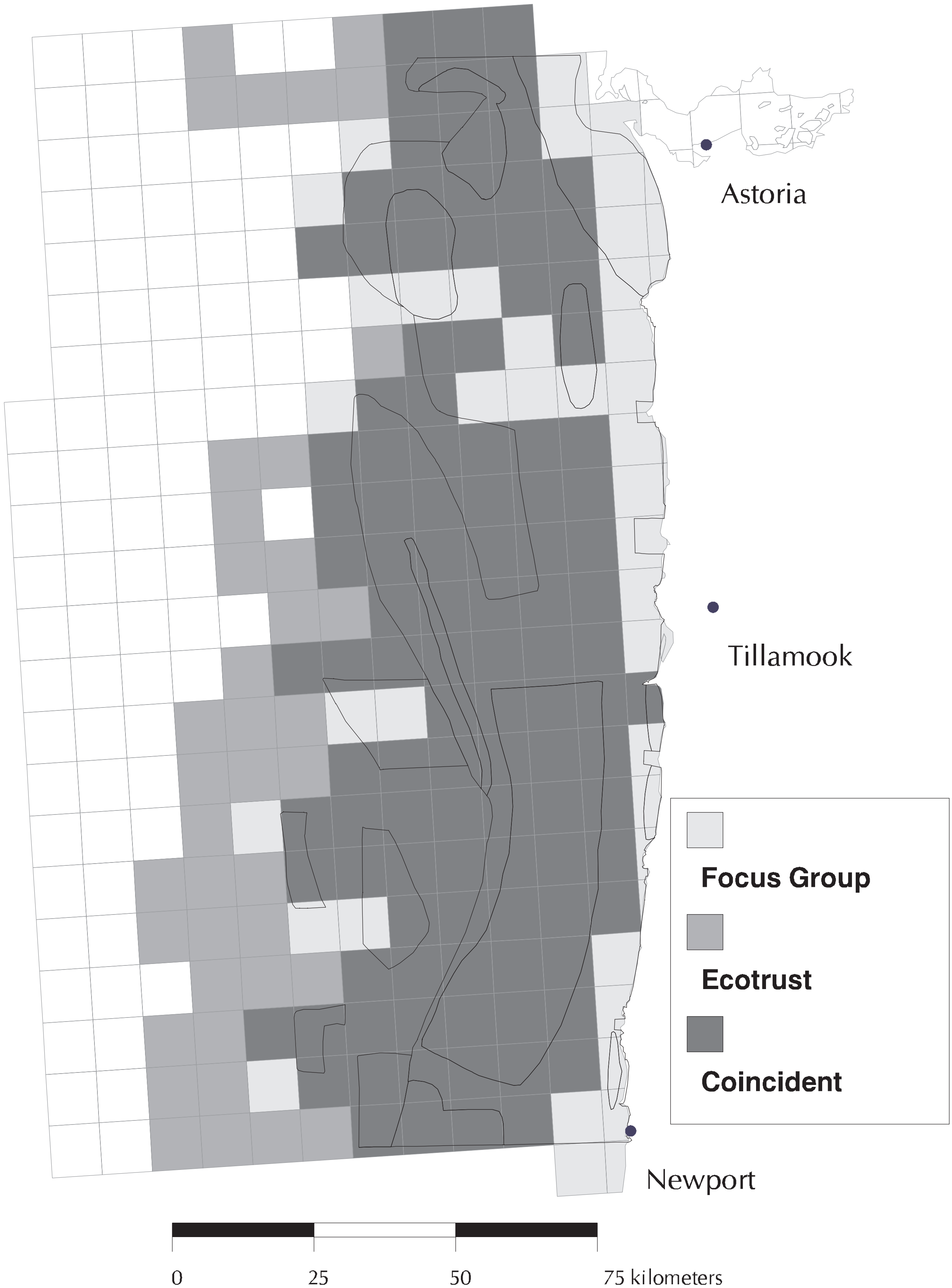


Coincidence of Focus Group and Ecotrust Effort

Small Footrope Trawl, Era 1 and Ecotrust 1997



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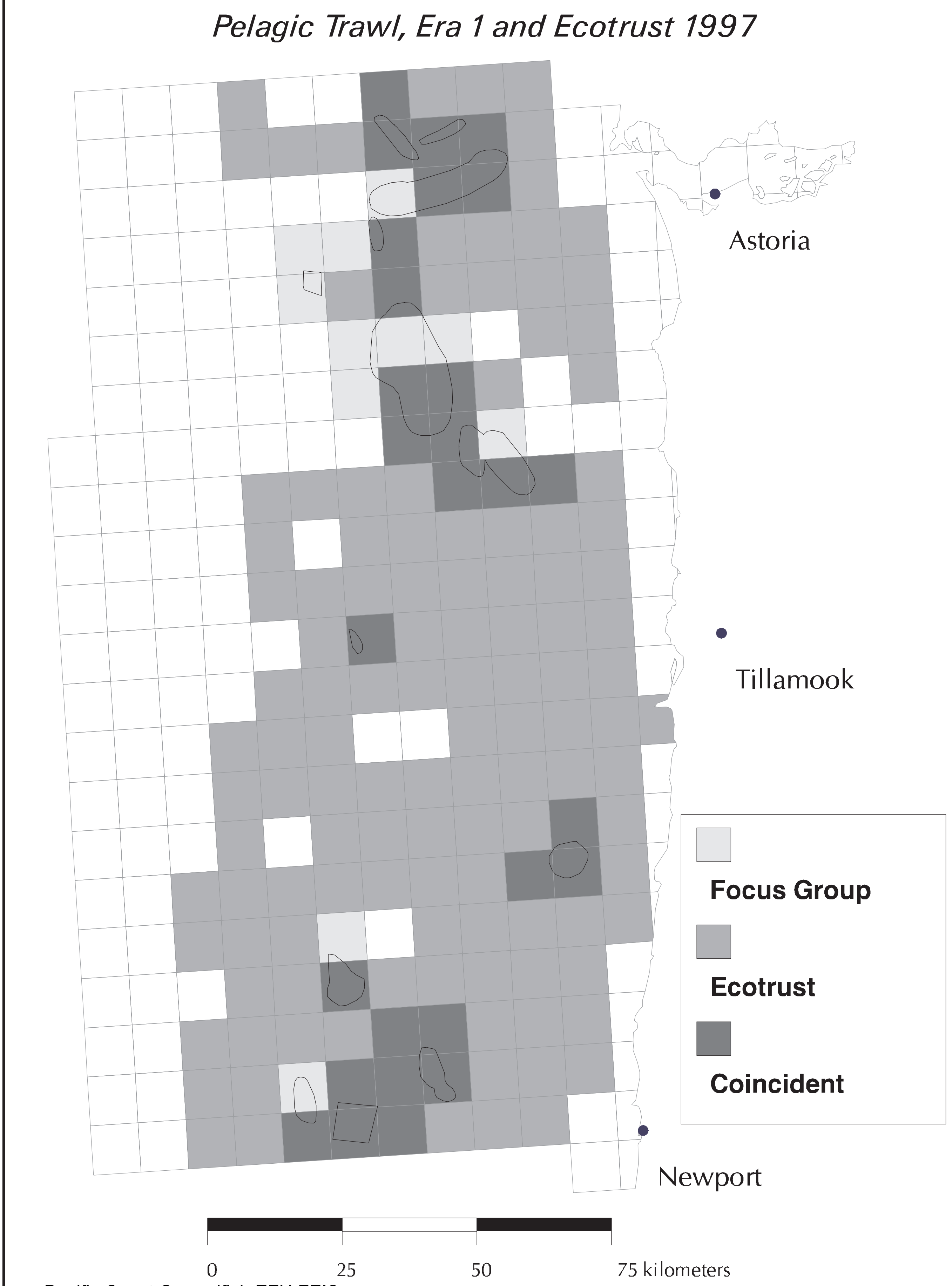

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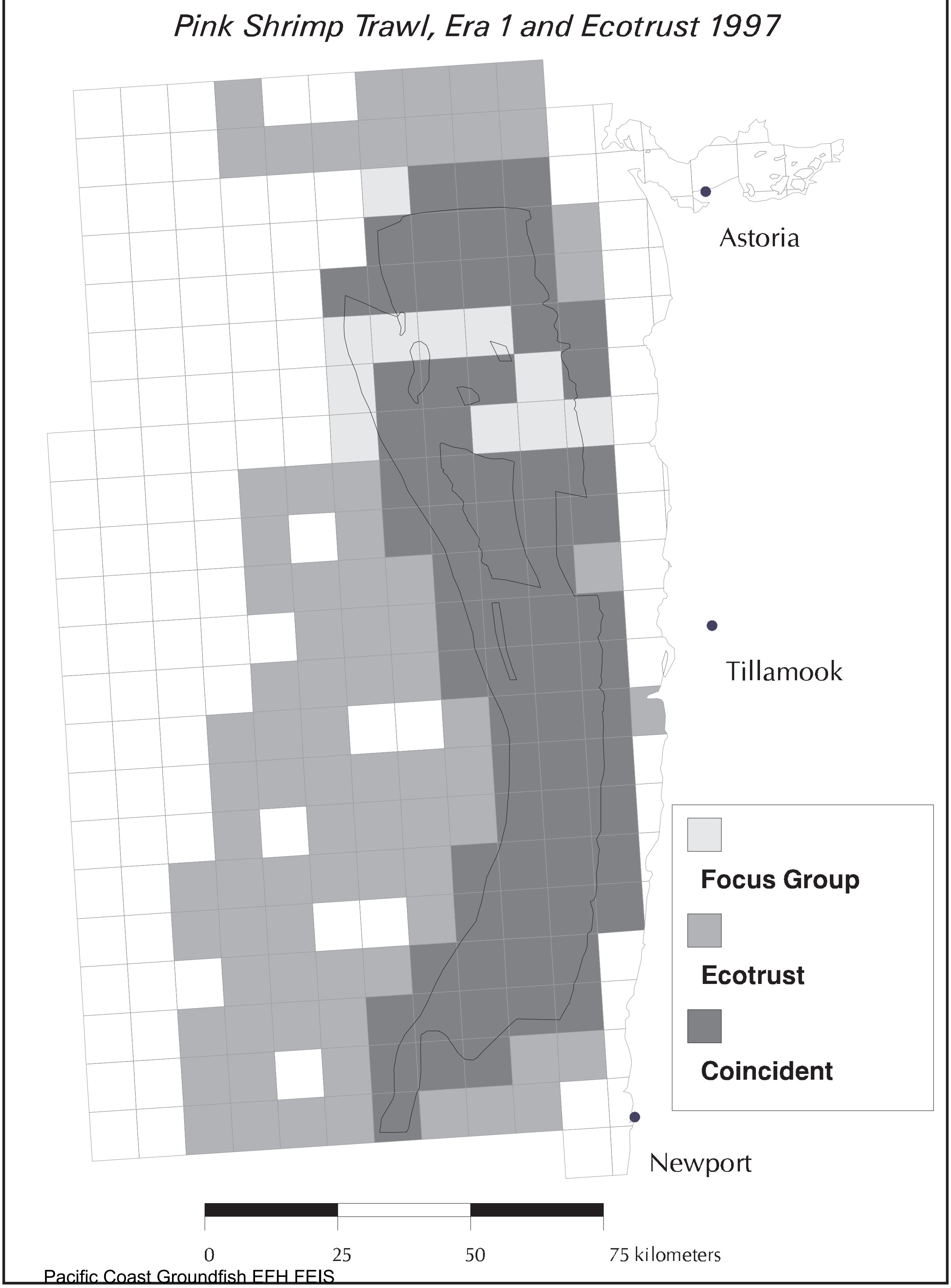

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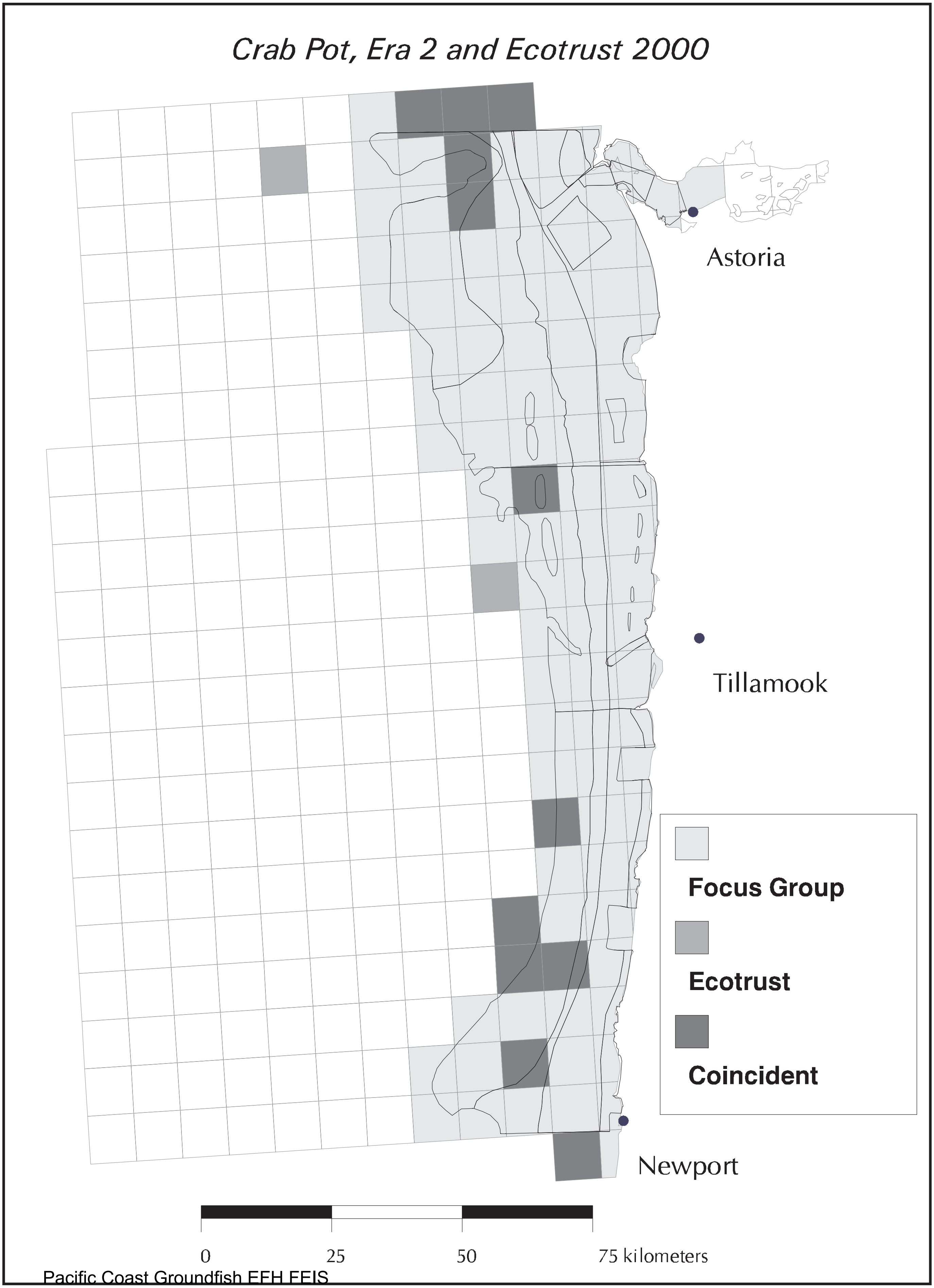

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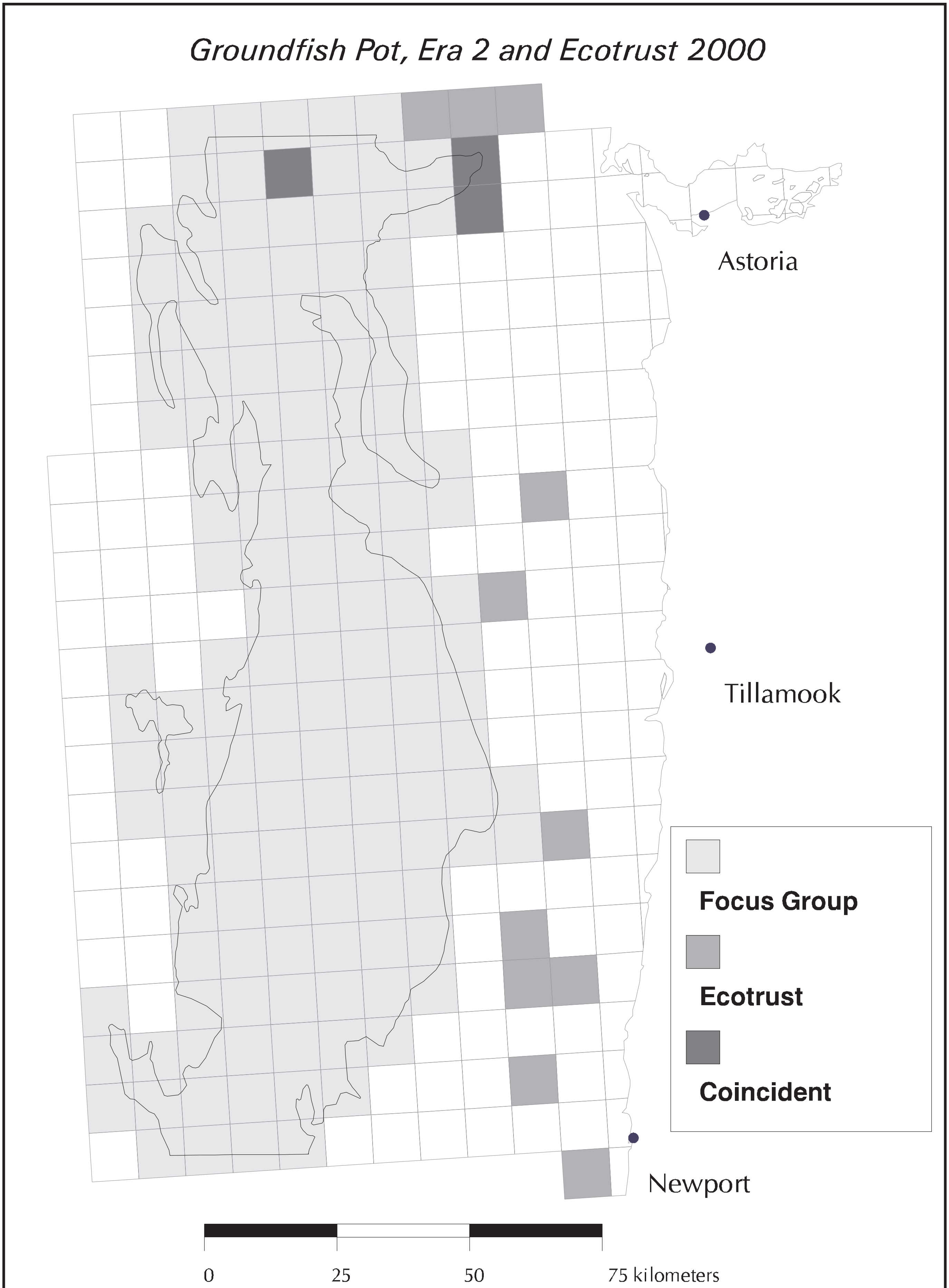
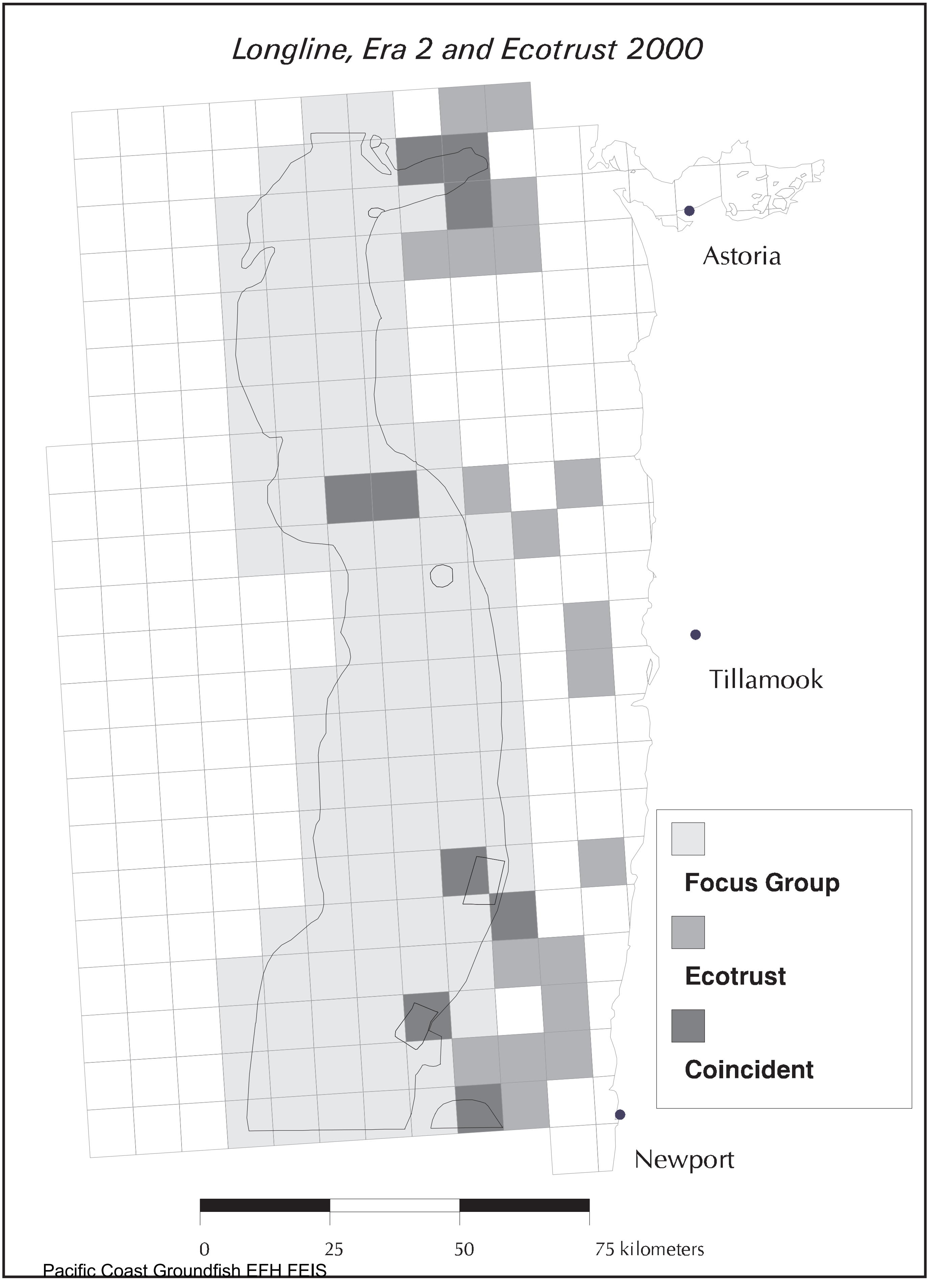
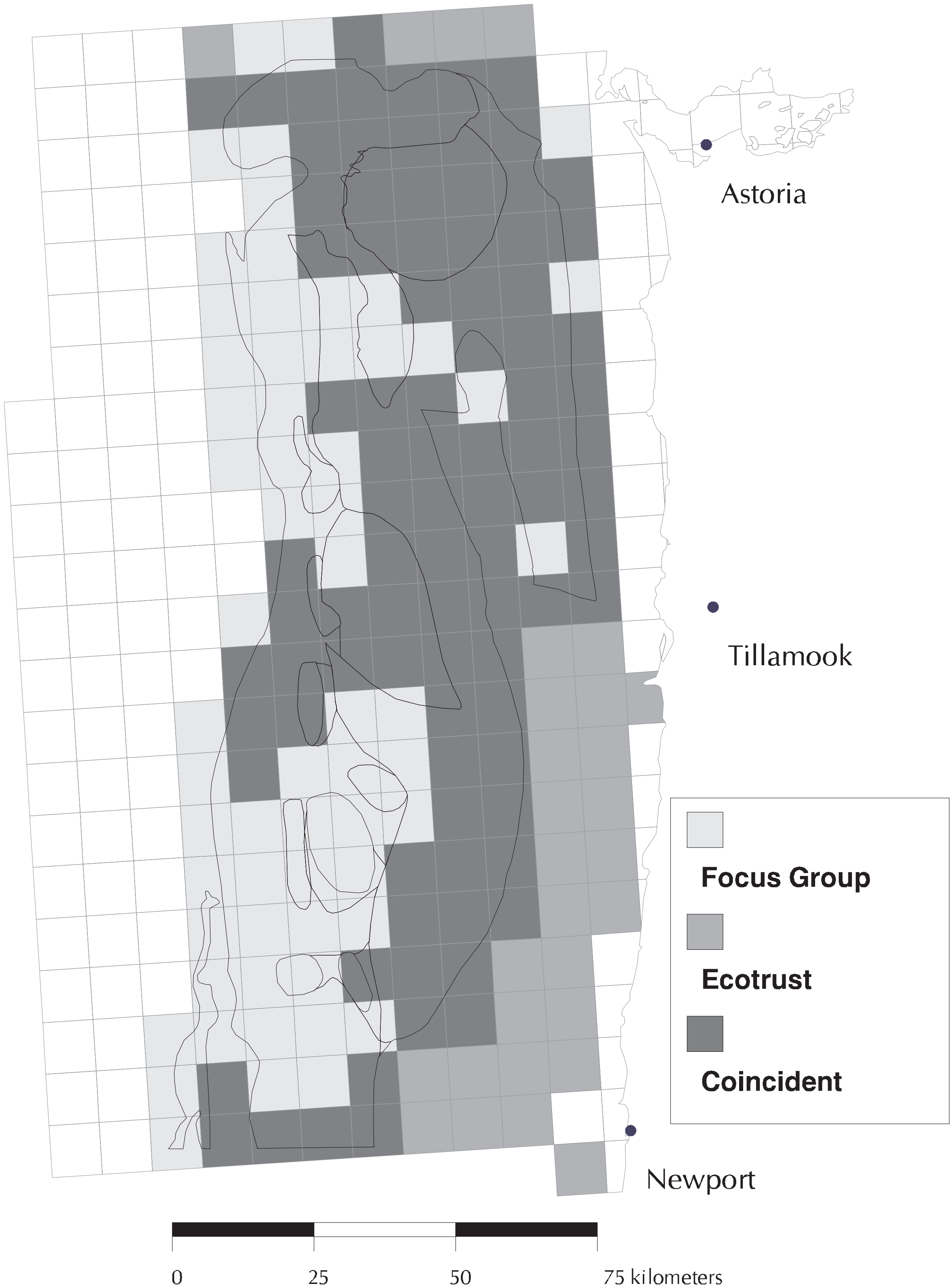


Coincidence of Focus Group and Ecotrust Effort



Coincidence of Focus Group and Ecotrust Effort

Large Footrope Trawl, Era 2 and Ecotrust 2000



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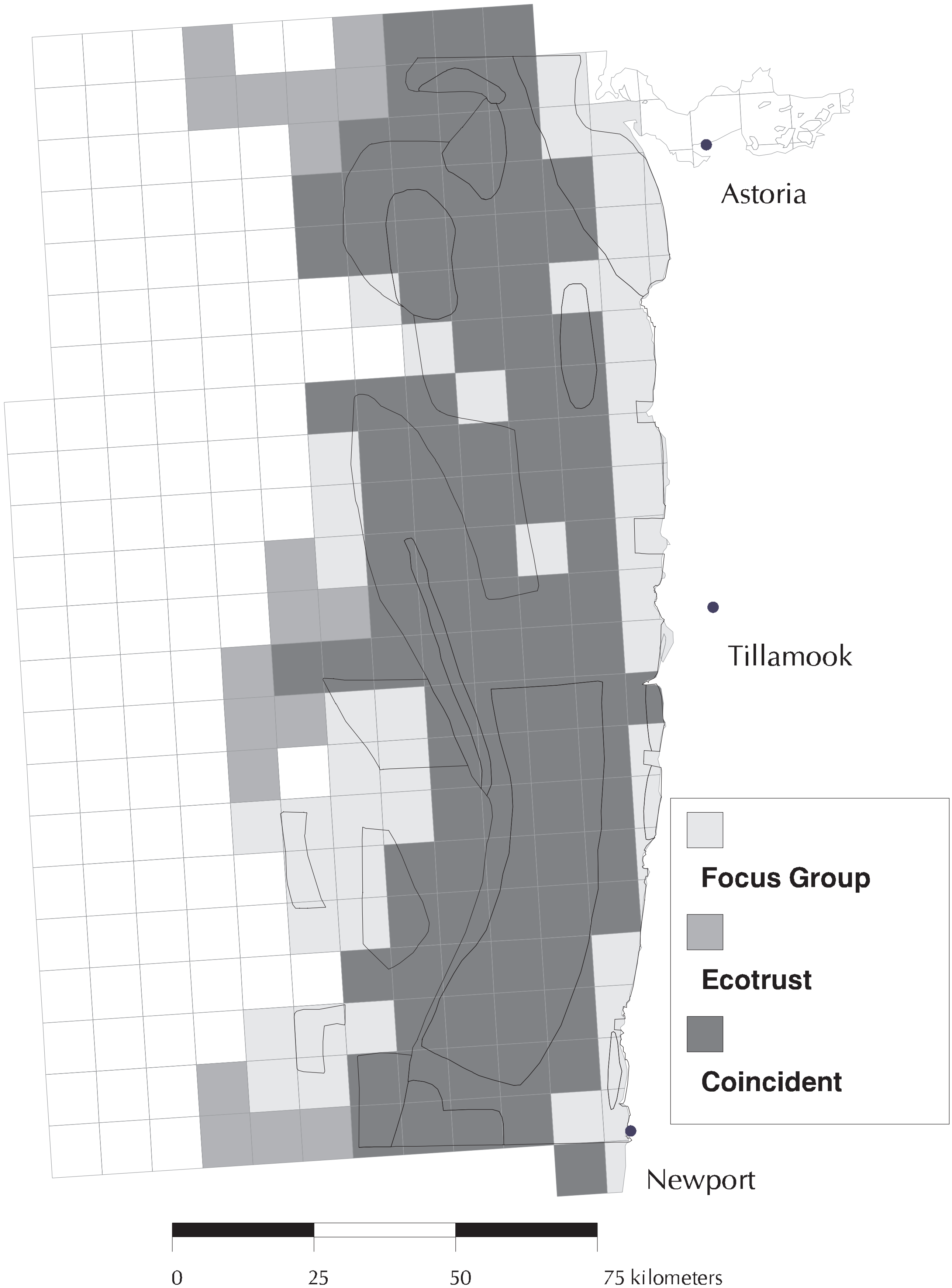

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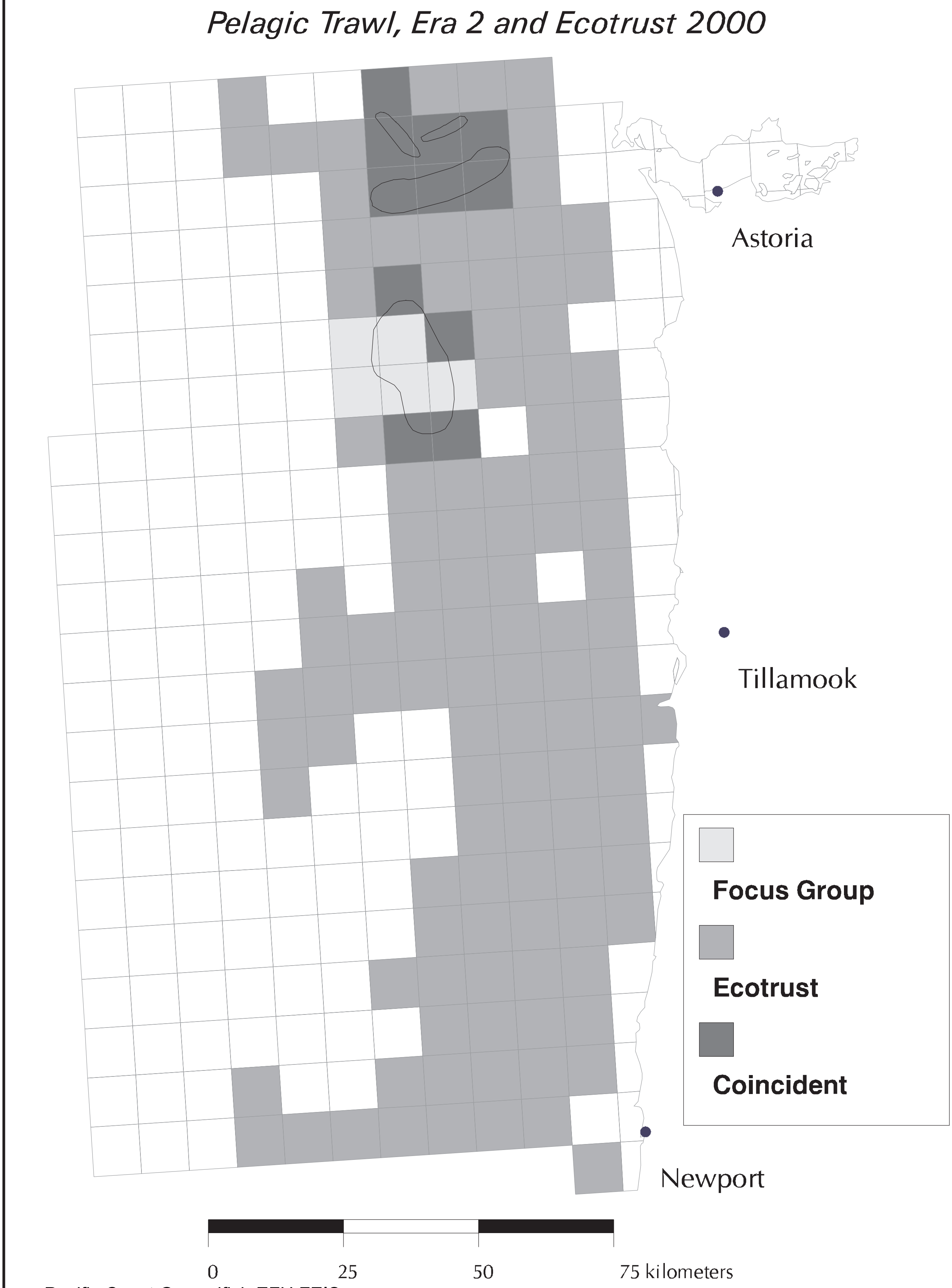

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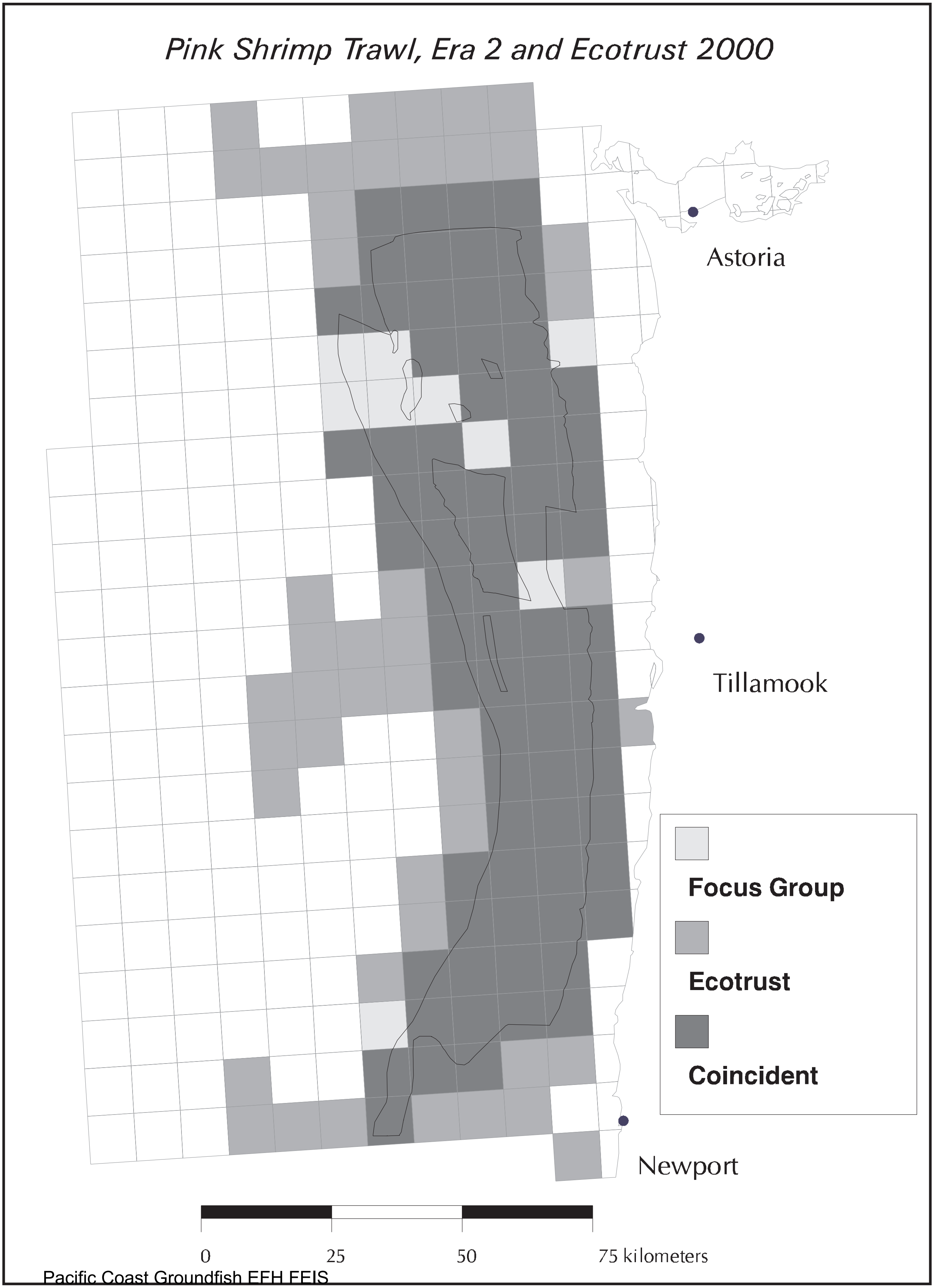
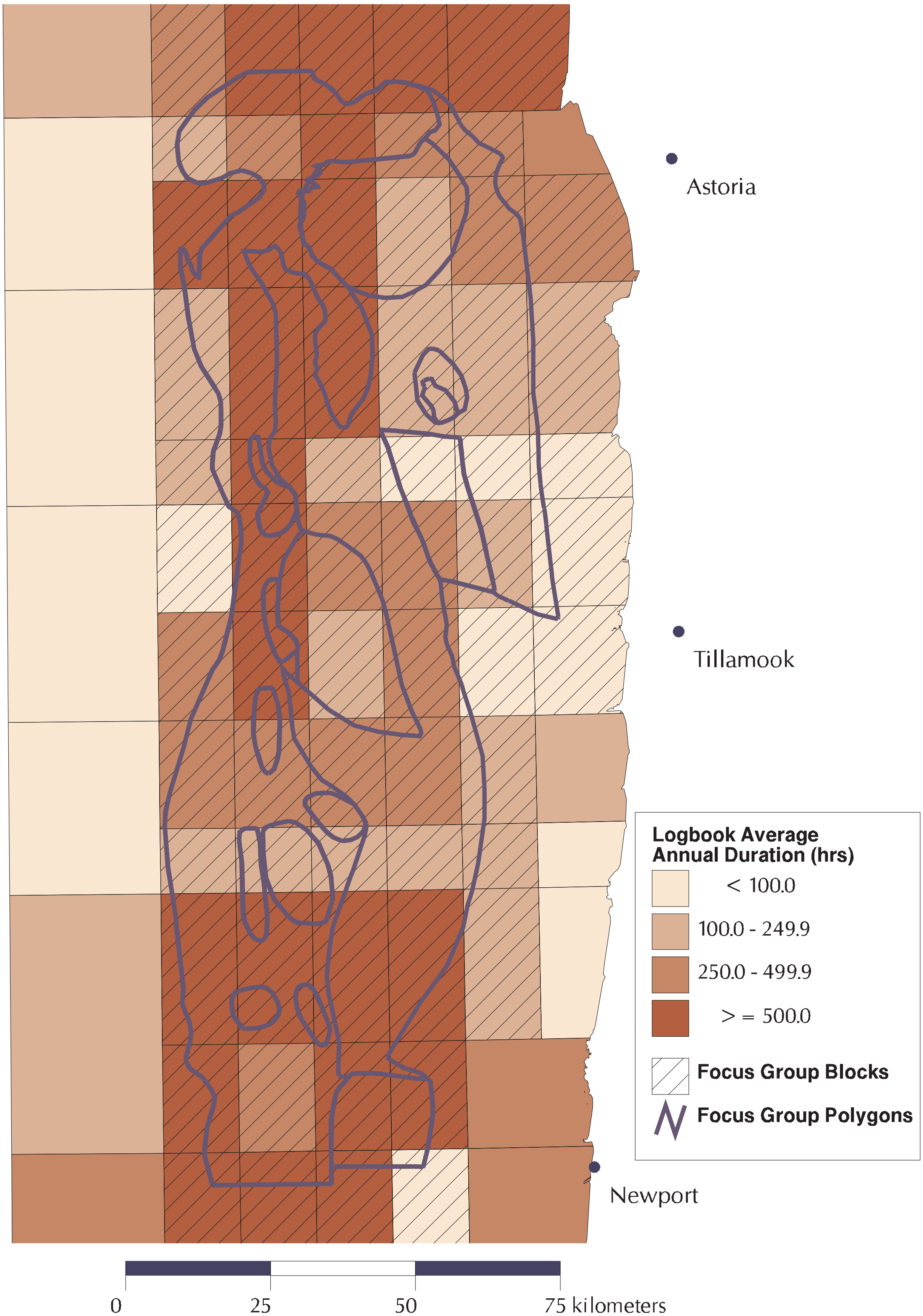


Appendix B

Focus Group and Trawl Logbook Comparison Maps

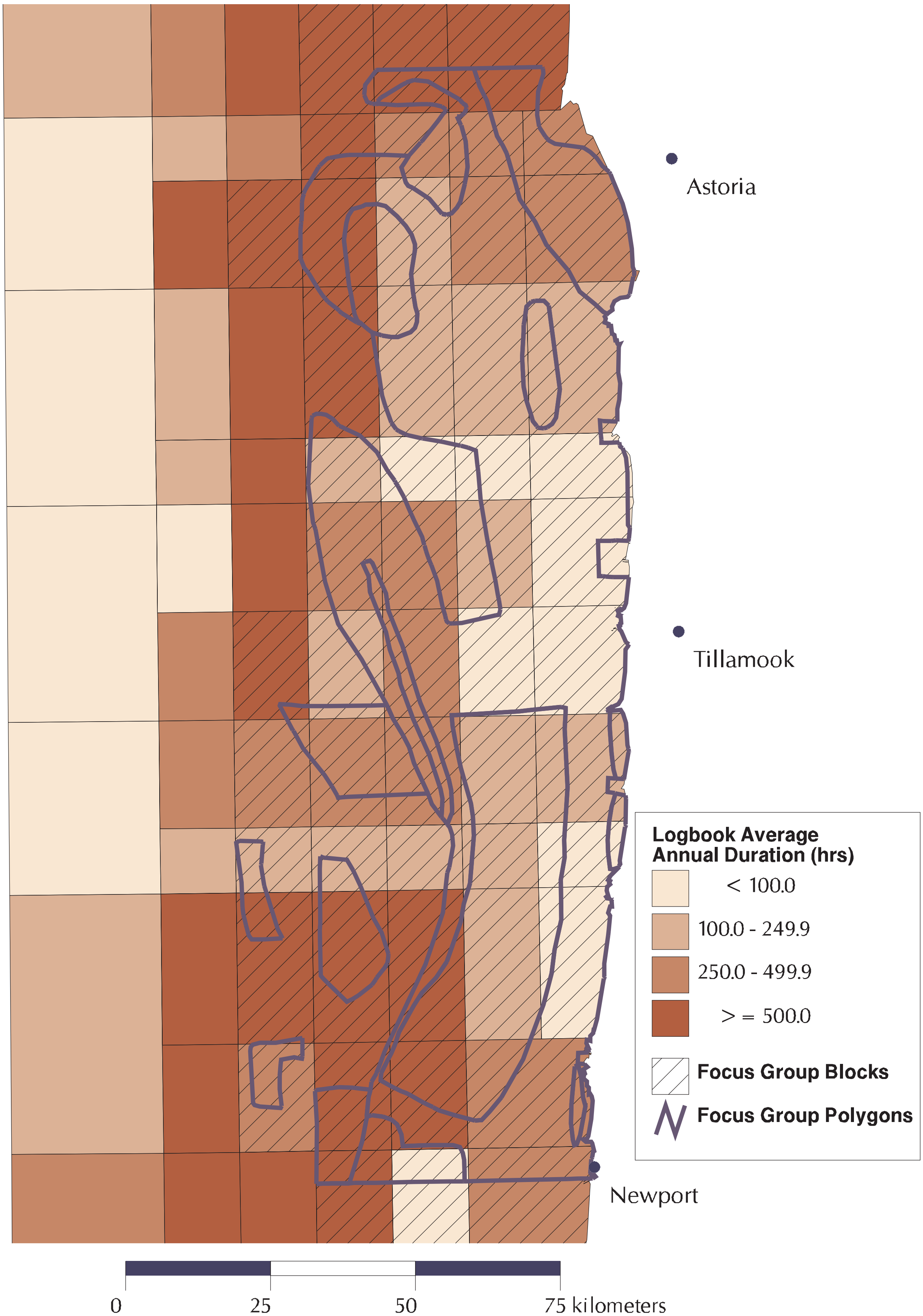
Coincidence of Focus Group and Logbook Effort

Large Footrope Trawl, Era 1 and Logbook 1987-1999

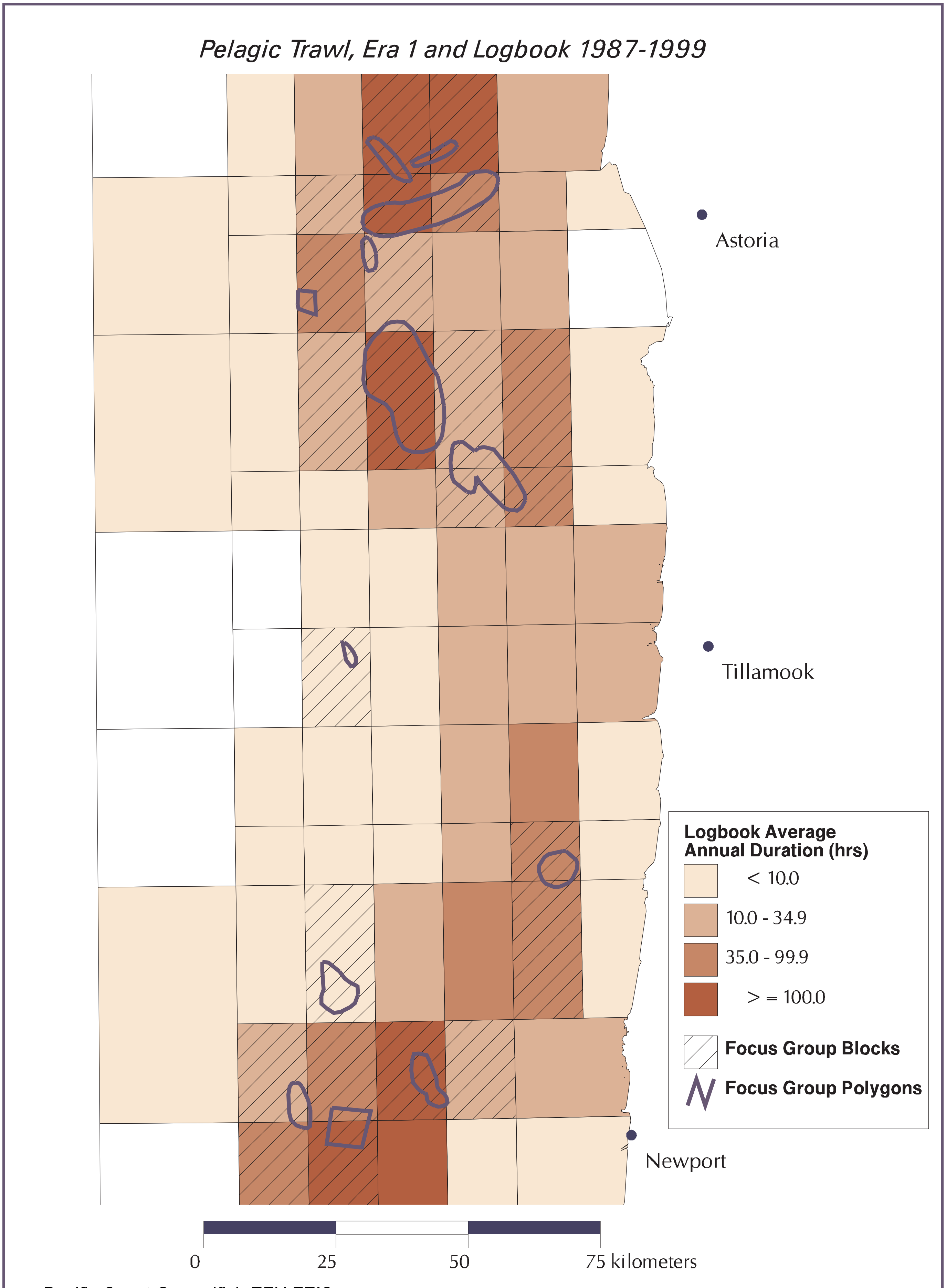


Coincidence of Focus Group and Logbook Effort

Small Footrope Trawl, Era 1 and Logbook 1987-1999

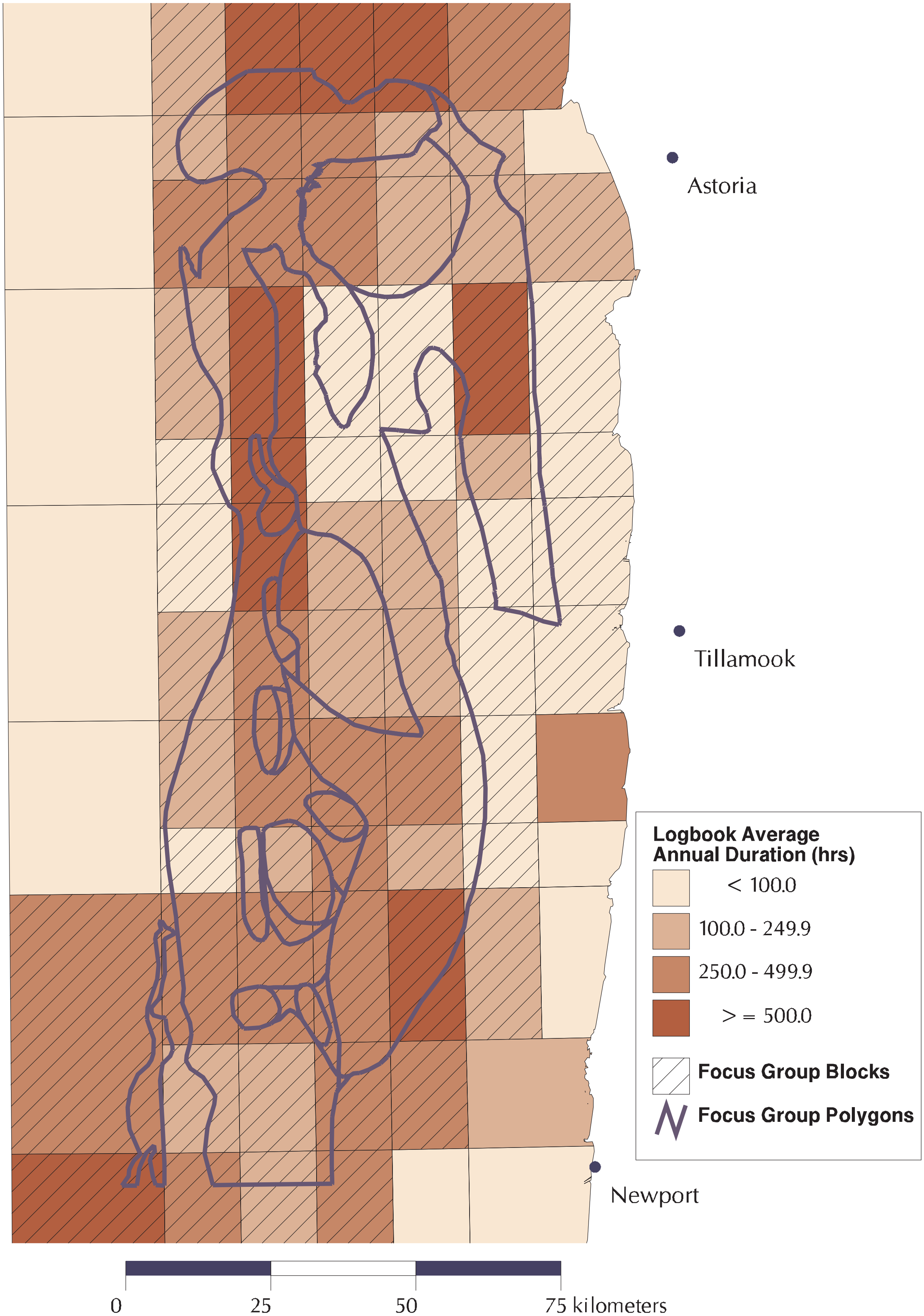


Coincidence of Focus Group and Logbook Effort



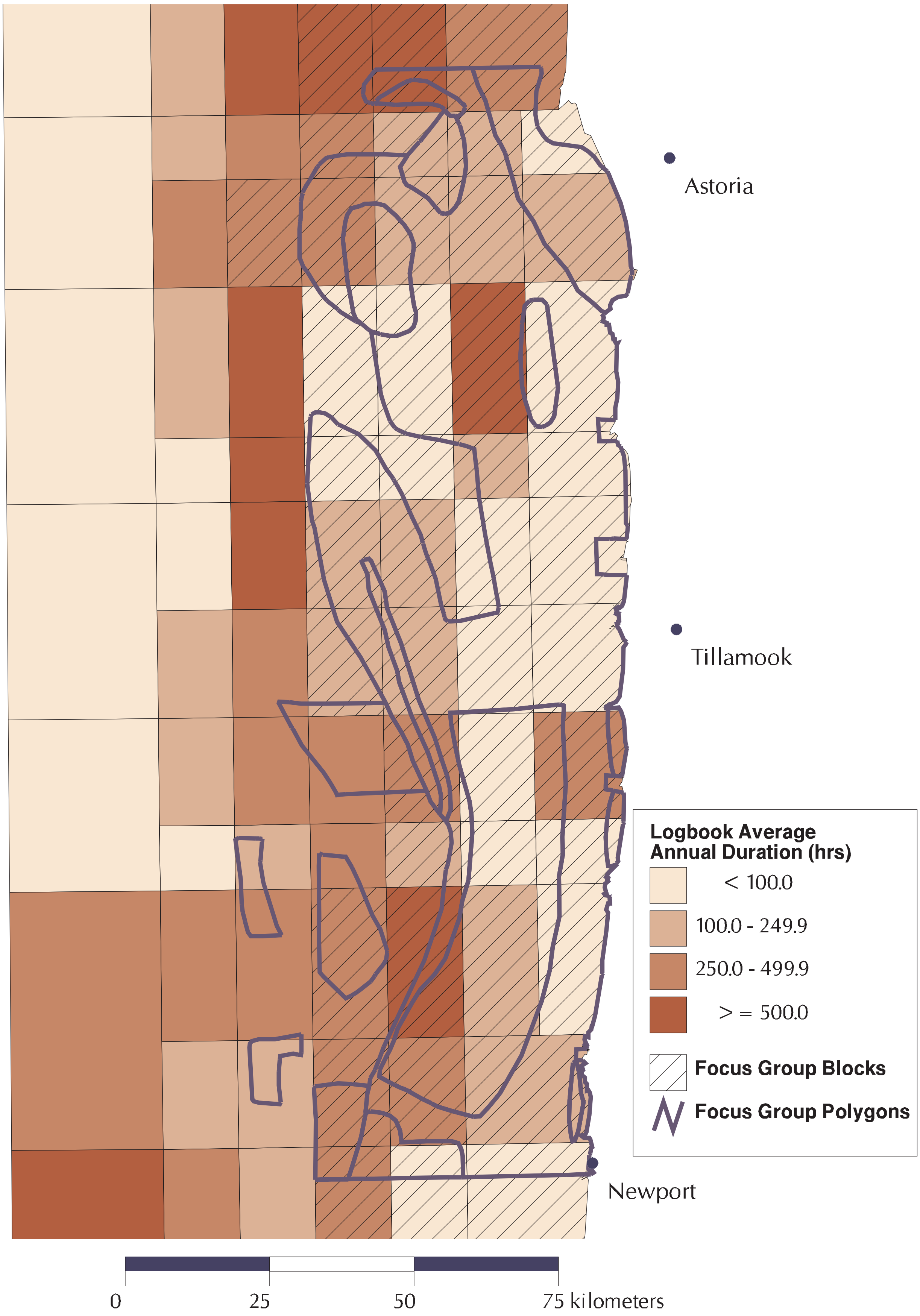
Coincidence of Focus Group and Logbook Effort

Large Footrope Trawl, Era 2 and Logbook 2000-2002

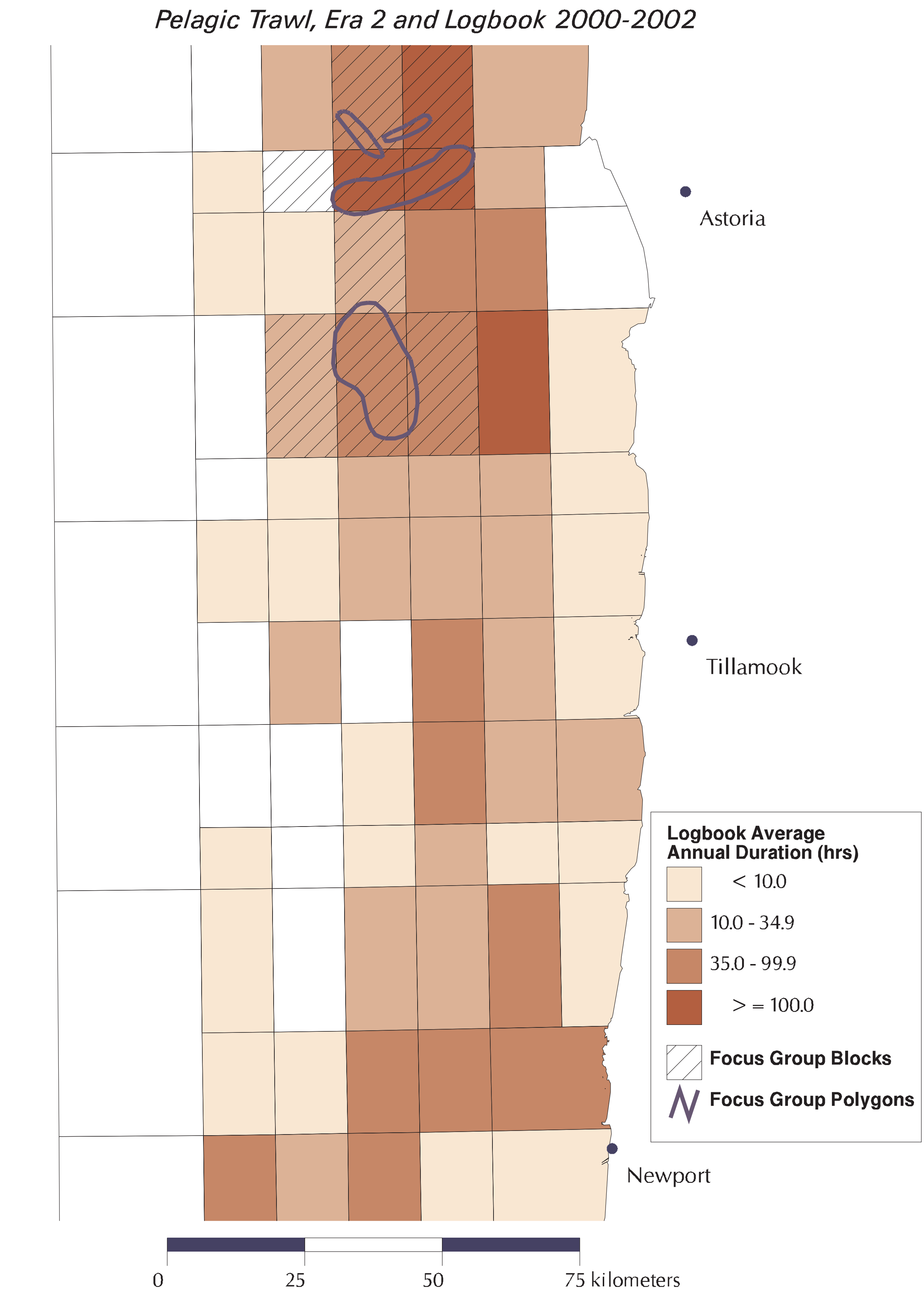


Coincidence of Focus Group and Logbook Effort

Small Footrope Trawl, Era 2 and Logbook 2000-2002



Coincidence of Focus Group and Logbook Effort



Appendix 13

Recreational Fishing

The impacts of recreational fishing on the marine ecosystem are not well understood. The following analysis investigates the known data and attempts to establish the spatial distribution of recreational fishing effort. The analysis is hindered due to the limitations of existing West Coast spatial data. Data for this analysis was compiled from the National Marine Fisheries Service through the Marine Recreational Fisheries Statistical Survey (MRFSS), which is a two-part survey to estimate the total catch and fishing effort of marine recreational anglers in the United States. The Pacific coast portion of this nation-wide survey covers the coasts of Washington, Oregon and California. The Party Charter Phone Survey (PCPS) is an effort-estimating alternative to the traditional MRFSS for marine recreational passenger boat fishing trips in the United States. The Pacific coast portion of this nation-wide survey covers only the coast of California. The Washington Ocean Sampling Program (WDFW-OSP) samples all ocean boat trips during the approximate ocean season of April-October each year and the Oregon Boat Survey (ODFW-ORBS) study samples ocean boat trips during same open season. The Washington Halibut Sampling Project (WDFW) uses catch record cards and field sampling to estimate halibut catch during the halibut season. The California Department of Fish and Game collects data via the California Ocean Boat Salmon Sampling program, which samples all ocean boat trips for salmon to estimate catch, effort and recover tags. The Central California Commercial Passenger Fishing Vessel Survey, which samples Commercial Passenger Fishing Vessel Ocean trips from Morro Bay to Eureka. Finally, data on billfish is obtained through the Pacific-Indian Ocean International Billfish Angling Survey, which estimates the catches of billfish for the state of California as well as the Pacific, and Indian Oceans.[1]

Due to data limitations, effort is defined in this analysis as numbers of fishing trips. The existing data on numbers of trips is broken down into regional information, which is further stratified into activities occurring within state and federal waters. None of the existing data refers to where within the physical environment this effort is concentrated (e.g. in the water column, on near/on the bottom). Even the existing data on recreational fishing has limitations. No data exists for 1990 thru 1992; there was no data for January and February of 1995; data on the Northern California region do not include boat trips targeting salmon from 1992-1997; similarly tuna trips from this region were not fully sampled nor were charter boats in this region due to refusals by boat owners. Experts familiar with these data sets believe the large spike in trip effort during 1981, seen over many of the charts, is due to sampling problems associated with the implementation of the programs.

[1] Recreational Fisheries Information Network (RecFIN). " RecFIN Program Contributors - Data Sources." May 20, 2004 <hhttp://www.psmfc.org/recfin>.

The regional breakdown of recreational fisheries data consists of four areas: Southern and Northern California, Oregon and Washington. The aggregation data from each region exists as a fifth category. Each region is further segregated into fishing activities that occur within federal waters (beyond three miles from shore) and activities that occur within state waters (within three miles of shore). Marine angling within state waters can be further stratified into activities occurring from shore (e.g., bank or beach fishing), those occurring on man made structures (e.g. piers, jetties, etc.), and boat based activities. Boat based activities occurring both within and outside of three miles from shore are generally categorized as private and rental boat fishing[2] and charter and party boat fishing. [3]

The data reflecting fishing effort in number of trips for boat based activities outside of three miles (Figure 1) illustrates heavy use of the these waters by anglers in the Southern California region. The effort in this region accounts for the majority of all boat-based fishing in federal waters over all regions. Trip data shows that fishing effort for all regions from 1981-1989 remained relatively constant. Trip numbers in 1980 were the only significant departure from this trend with approximately three and a half times more trips in this year than any other in the 1980's. The number of trips for all regions throughout the mid-1990s through 2003 remains relatively constant. While effort has remained stable over the last 10 years, these numbers are lower in almost every case than trip numbers seen in the 1980's.

The data on private and rental boat fishing in federal waters (Figure 2) illustrates a steadily increasing trend in the number of trips throughout the 1980s. The number of trips taken by anglers to federal waters rose from approximately 330,000 trips in 1981 to 880,000 trips in 1988. Trips during 1990 thru 2003 remained relatively stable and the numbers of trips made by anglers during this period were generally lower than those made during the 1980s.

Overall, party and charter boats took fewer trips beyond the three-mile threshold (Figure 3) than did private and rental boats. Party boat and charter boat anglers made 732,000 trips in 1982, which was the highest number of trips recorded during the 1980s. Effort declined the following year but began to rebound slightly in 1984, and increased thru 1986. Effort peaked again in 1988 with 628,000 trips. Data from the early and mid 1990s shows only anglers from the Southern California region making trips. Effort by these anglers remained almost static in 1993 and 1994 around 475,000 trips, with a decline to 240,000 trips in 1995. After 1995, Northern California anglers begin to reappear in the data and a slight increasing trend is observed from 1995 thru 1998. Trip numbers increase to 412,000 in 2000 but decline below this mark for rest of dataset.

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[2] Rental boats are defined as rented boats that are operated by the renter. Private boats are defined as boats belonging to an individual. Source: MRFSS

[3] Partyboat is defined as a boat on which fishing space and privileges are provided for a fee. Anglers on these full or half day trips usually do not know the other anglers on the boat. A charter boat: A boat operating under charter for a specific price, time, etc. and the participants are part of a pre-formed group. Source: MRFSS

Data from within the three-mile threshold show the number of boat-based fishing trips (Figure 4) were higher in every year than the number of trips beyond three miles. In contrast to the data from outside the three-mile threshold, 1980 showed the least amount of effort by boats fishing waters within three miles of shore. The number of trips jumped from just about 1 million in 1980 to over 3 million in 1981. Effort was at least 1.5 million trips each year over the last two decades. Anglers from the Southern California region participated in the majority of these trips with Northern California anglers engaging in the next highest number of trips.

Private and rental boat trips taken within three miles from shore (Figure 5) leaps from close to 500,000 in 1980 to just fewer than 1.8 million trips in 1981. Trip numbers remain this high until 1986 when they increase again to 2.3 million. Effort remains high through the end of the 1980s with a peak of 2.45 million trips in 1987 before declining to 1.7 million trips in 1989. The mid 1990s saw trip numbers increase again to 1.9 million trips in 1994, followed by two years of decline. Trip numbers remained relatively stable from 1996 thru 1999. The leveling off in the late 1990s was followed by yet another increase in trip numbers from 1.5 million in 2000 to just over 2 million in 2003.

Trips by party and charter boats within three miles from shore (Figure 6) showed two years of high trip numbers during the 1980s. Effort in 1981 and 1982 was 1.3 and 1.6 millions trips respectively. Trips from 1984 thru 1990 showed some variation with a trip high occurring in 1990 at just over one million trips and a low occurring in 1987 with just over 750,000 trips. The mid 1990s thru 2003 showed a bimodal distribution with peaks of 996,000 in 1995 and 785,000 in 2000. The fewest number of trips occurred in 2002 at 334,000.

Shore based fishing trips (Figure 7) remained around 2,500,000 for all regions during the 1980’s with the Southern California region again recording the highest number of trips in each year. Shore based fishing effort has declined from the levels recorded during the 1980’s over the last decade. The Northern California region makes up a much higher percentage of the number of trips taken by anglers since 1993 than it did during the 1980’s. Effort in this region matched or eclipses that of Southern Californian anglers in 1995, 1997 and 2000.

Shore based fishing from beach and banks (Figure 8) showed a trend of higher trip numbers during the 1980’s than during the mid 1990s thru 2003. Trip numbers during the 1980s peaked in 1981 around 1,400,000 trips but remained above 1,000,000 trips from 1981-1985. Effort was down in the 1990s from trips recoded in 1981-1985. Trips peaked in 1996 with just over 800,000 trips, followed by years of declining trip numbers. The Southern California region had the most number of the trips during the 1980s but Northern California was close behind. This dynamic shifted in the mid 1990s thru 2003 with Northern California region showing the highest fishing effort in every year over the period.

The regional dominance of Northern California effort in the late 1990s thru 2003 shifts back to Southern California when looking at effort from man made structure fishing

(Figure 9). As with beach and bank fishing, the effort is greater in the 1980's than the 1990s thru 2003, and Southern California dominates the regional effort for the early time period. Effort for the mid 1990s thru 2003 is also highest in the Southern California region but the Northern California region begins to make up a larger portion of the overall effort.

Recreational fishing on the West Coast focuses mainly on two types of species; pelagic species (i.e. salmon and tunas) and benthic species (i.e. flounders and rockfish). Pelagic species are most commonly taken by during boat based fishing activities. Marine anglers targeting pelagic species use a variety of fishing techniques ranging from hook and line fishing, to mid water trolling, to netting. Shore based angler typically use hook and line and may take part in activities such as pier fishing or surfcasting.

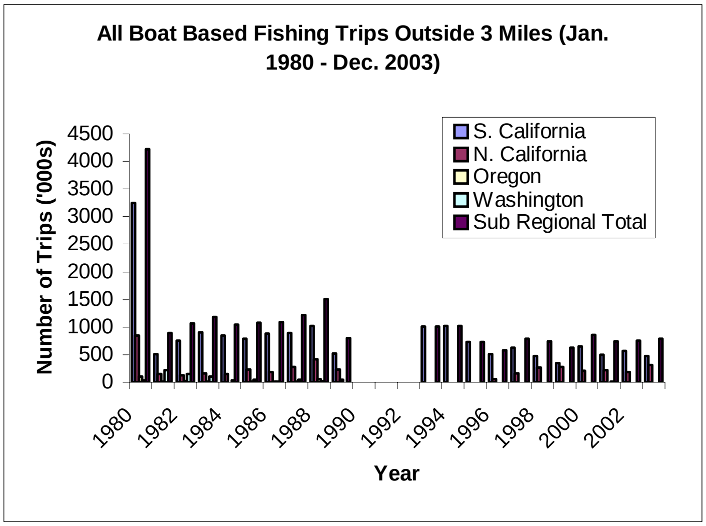


Figure 1

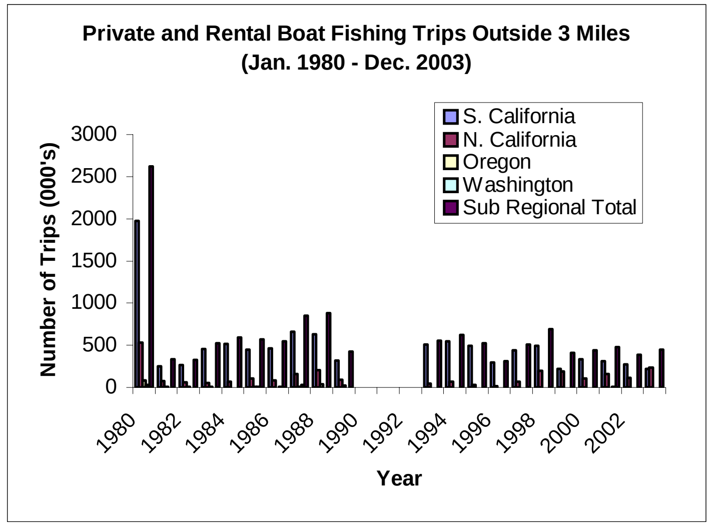
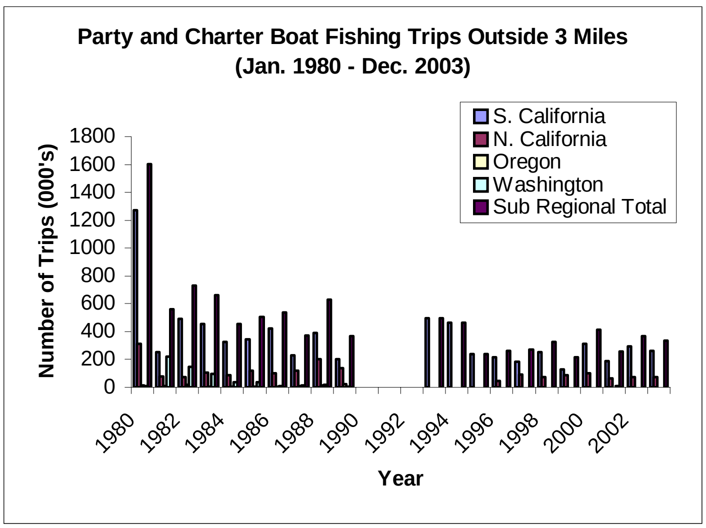


Figure 2



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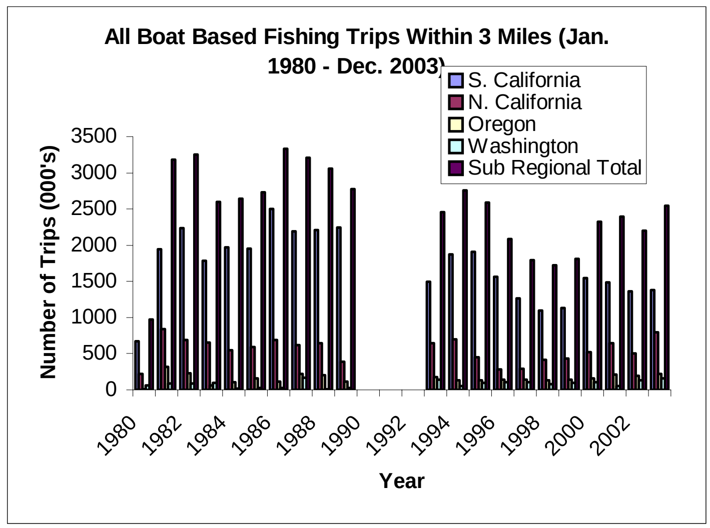

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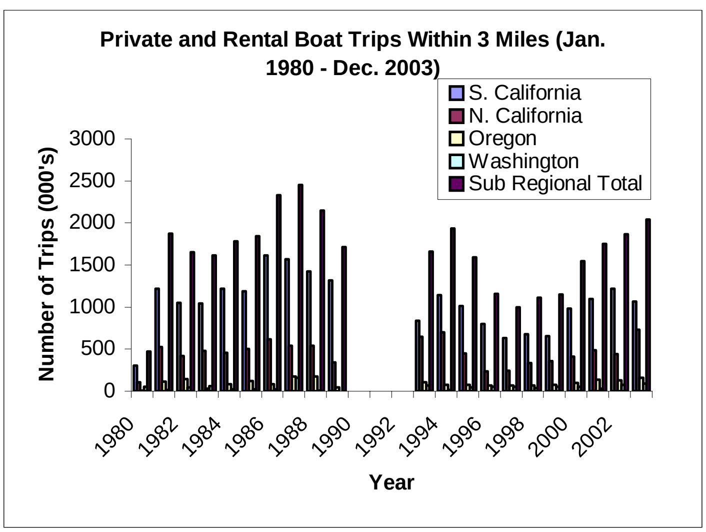

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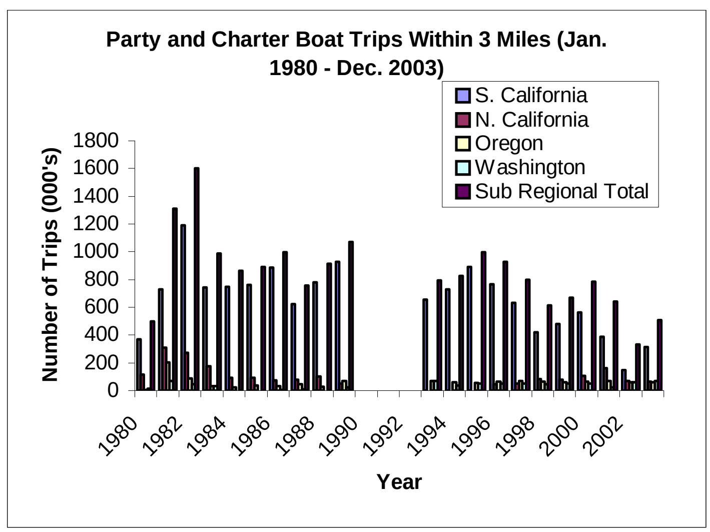

Figure 6

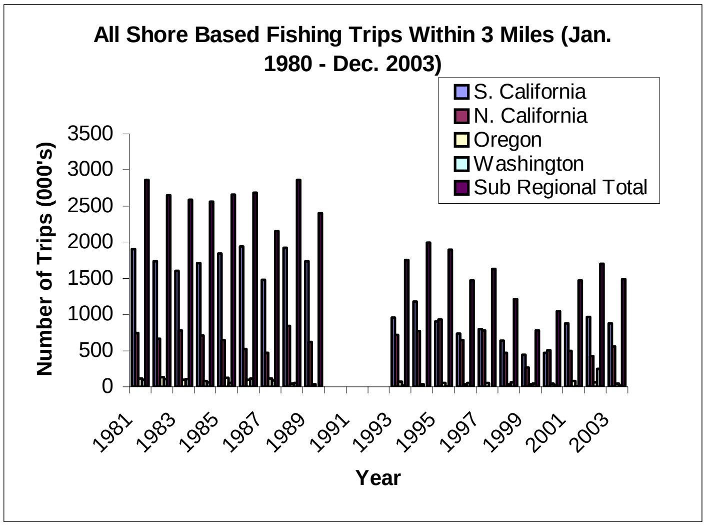

Figure 7

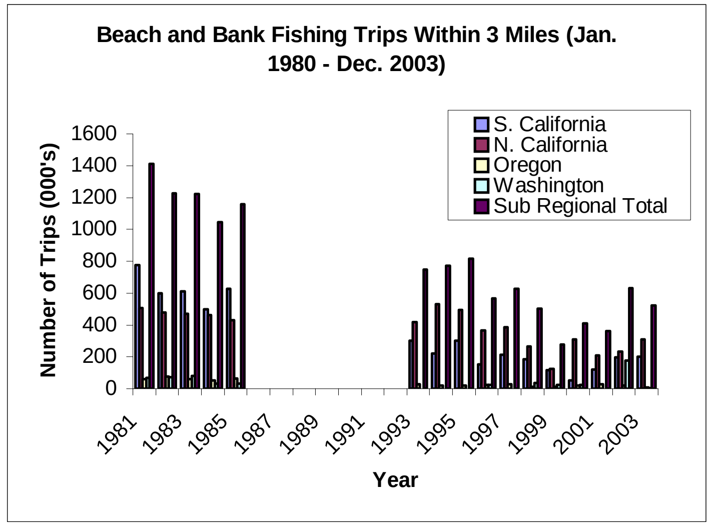

Figure 8

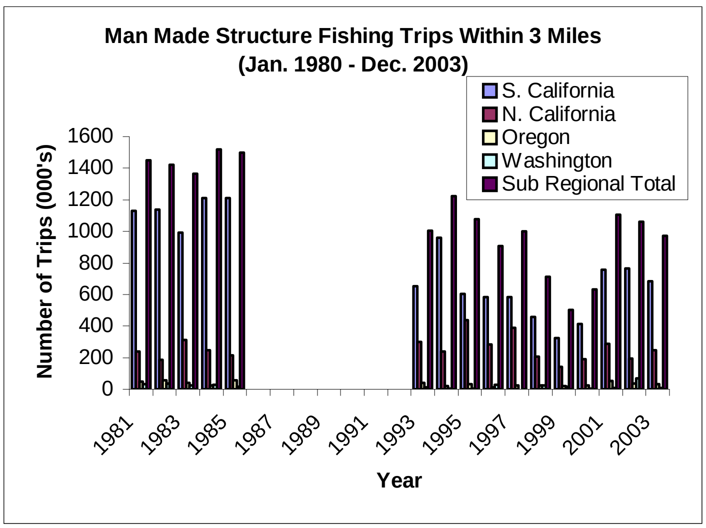

Figure 9

Appendix 14

NON-FISHING IMPACTS TO ESSENTIAL FISH HABITAT AND RECOMMENDED CONSERVATION MEASURES

National Marine Fisheries Service (NOAA Fisheries)
Alaska Region
Northwest Region
Southwest Region

Editors[1]
Jeanne Hanson, Mark Helvey, Russ Strach

Contributors[1]
Lt. Mark Boland, Tracy Collier, Bob Donnelly, Jeanne Hanson, Mark Helvey, Ron A. Heintz, Thom Hooper, DeAnee Kirkpatrick, Brian Lance, Marc Liverman, Matt Longenbaugh, Kristin McCully, Nancy Munn, Ben Meyer, Ken Phippen, Nat Scholz, John Stadler, Dan Tonnes, Susan Walker

Reviewers[1]
Tim Beechie, Karen Cantillon, Mark Carls, Eric Chavez, Bryant Chesney, Brian Cluer, Natalie Consentino-Manning, Joe Dillon, Ron Heintz, Bob Hoffman, Scott Johnson, K. Koski, Stacy Li, Leah Mahan, Jon Mann, Adam Moles, Brian Mulvey, Larry Peltz, Stanley D. Rice, Maggie Sommer, Bill Wilson, Mary Yoklavich

[1]Listed in alphabetical order.

August 2003
Version 1

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ACRONYMS AND ABBREVIATIONS

AAPA	American Association of Port Authorities
ACZA	ammoniacal copper zinc arsenate
AFS	American Fisheries Society
ATTF	Alaska Timber Task Force
BMPs	best management practices
BOD	biochemical oxygen demand
BTA	best technology available
CCA	chromated copper arsenate
CSREEs	Cooperative State Research, Education, and Extension
CWA	Clean Water Act
dB	decibel
DoN	Department of the Navy
Ecology	Washington State Department of Ecology
EFH	Essential Fish Habitat
EPA	U.S. Environmental Protection Agency
ESA	Endangered Species Act
FC	fecal coliform (bacteria)
FERC	Federal Energy Regulatory Commission
FIFRA	Federal Institute, Fungicides, and Rodenticide Act
FL	fork length
FMCs	Fishery Management Councils
FREP	Futilizer Research and Education Program
GIS	geographical information system
GOA	Gulf of Alaska
Hz	Hertz
IPM	integrated pest management
LTF	log transfer facilities
LWD	large woody debris
m/s^2	meters per second squared
Magnuson-Stevens Act	Magnuson-Stevens Fishery Conservation and Management Act
NAWQA	National Water Quality Assessment
NEPA	National Environmental Policy Act
NMDMP	National Marine Debris Monitoring Program
NMFS	National Marine Fishery Service
NOAA	National Oceanic and Atmospheric Administration
NPDES	National Pollution Discharge Elimination System
NPFMC	North Pacific Fishery Management Council
NPPC	Northwest Power Planning Council
NRC	National Research Council
OCS	outer coastal shelf
OWRRI	Oregon Water Resources Research Institute
PAH	polyaromatic hydrocarbon
PBDE	polybrominated diphenyl ether
PFMC	Pacific Fishery Management Council
PNPCC	Pacific Northwest Pollution Control Council
RPWAST	Rich Passage Wave Action Study Team
SCS	Soil Conservation Service
SPL	sound pressure levels
SSC	suspended sediment concentration

TSS	total suspended solids
USACE	U.S. Army Corps of Engineers
USDA	U.S. Department of Agriculture
USFWS	U.S. Fish and Wildlife Service
USGS	U.S. Geological Survey
WCS	water control structure
WDFW	Washington State Department of Fish and Wildlife
ZOD	zone of deposit

1.0 INTRODUCTION

Background on Essential Fish Habitat

In 1996, the U. S. Congress added new habitat conservation provisions to the Magnuson-Stevens Fishery Conservation and Management Act (Magnuson-Stevens Act), the federal law that governs U.S. marine fisheries management. The renamed Magnuson-Stevens Act mandated the identification of Essential Fish Habitat[2] (EFH) for federally managed species and consideration of measures to conserve and enhance the habitat necessary for these species to carry out their life cycles.

The act also requires federal agencies to consult with National Oceanic and Atmospheric Administration (NOAA) Fisheries on all actions, or proposed actions, permitted, funded, or undertaken by the agency, that may adversely affect[3] EFH. Federal agencies do this by preparing and submitting an EFH Assessment to NOAA Fisheries. The EFH Assessment is a written assessment of the effects of the proposed federal action on EFH. Regardless of federal agency compliance to this directive, the act requires NOAA Fisheries to recommend conservation measures to federal as well as state agencies once it receives information or determines from other sources that EFH may be adversely affected. These EFH conservation recommendations are provided to conserve and enhance EFH by avoiding, minimizing, mitigating, or otherwise offsetting the adverse effects to EFH.

Activities proposed to occur in EFH areas do not automatically require consultation. Consultations are triggered only when the proposed action may adversely affect EFH, and then, only federal actions require consultation.

By providing EFH conservation recommendations before an activity begins, NOAA Fisheries may help prevent habitat damage before it occurs rather than restoring it after the fact, which is less efficient, unpredictable, and often more costly. This could ultimately save American taxpayers millions of dollars in habitat restoration funds and could save industries from having to remedy environmental problems down the road. Furthermore, EFH conservation will lead to more robust fisheries, providing benefits to coastal communities and commercial and recreational fishers alike (Benaka 1999).

This consultation process is usually integrated into existing environmental review procedures in accordance with the National Environmental Policy Act (NEPA), Endangered Species Act (ESA), or the Fish and Wildlife Coordination Act, for instance, to provide the greatest level of efficiency.

Within 30 days of receiving NMFS' conservation recommendations, federal action agencies must provide a detailed response in writing to NMFS. The response must include measures proposed for avoiding, mitigating, or offsetting the impact of a proposed activity on EFH. State agencies are not required to respond to EFH conservation recommendations. If the federal action agency chooses not to adopt NMFS' conservation recommendations, it must provide an explanation. Examples of federal action agencies that

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[2] EFH is defined as "those waters and substrate necessary to fish for spawning, breeding, feeding, or growth to maturity." *Waters* include aquatic areas and their associated physical, chemical, and biological properties. *Substrate* includes sediment underlying the waters. *Necessary* means the habitat required to support a sustainable fishery and the managed species' contribution to a healthy ecosystem. *Spawning, breeding, feeding, or growth to maturity* covers all habitat types utilized by a species throughout its life cycle.

[3] Adverse effect is any impact which reduces the quality and/or quantity of EFH. Adverse effects may include direct or indirect physical, chemical, or biological alterations of the waters or substrate and loss of, or injury to benthic organisms, prey species, and their habitat, and other ecosystem components. Adverse effects may be site-specific or habitat-wide impacts, including individual, cumulative, or synergistic consequences of actions [50 CFR 600.910(a)]

permit or undertake activities that may trigger the EFH consultation process include, but are not limited to, the U.S. Army Corps of Engineers (USACE), the U.S. Environmental Protection Agency (EPA), the Federal Energy Regulatory Commission, and the Department of the Navy (DoN). NOAA's Fishery Management Councils (FMCs) may also choose to comment on proposed actions that may adversely impact EFH.

Significance of Essential Fish Habitat

The waters and substrate that comprise EFH designations under the jurisdiction of the FMCs are diverse and widely distributed. They are also closely interconnected with other aquatic and terrestrial environments.

From a broad perspective, EFH is the geographic area where the species occurs at any time during its life. This area can be described in terms of ecological characteristics, location, and time. Ecologically, EFH includes waters and substrate that focus distribution (e.g., migration corridors, spawning areas, rocky reefs, intertidal salt marshes, or submerged aquatic vegetation) and other characteristics that are less distinct (e.g., turbidity zones, salinity gradients). Spatially, habitats and their use may shift over time due to climate change, human activities, geologic events, and other circumstances. The type of habitat available, its attributes, and its functions are important to species productivity, diversity, health, and survival.

The following discussion addresses non-fishing activities that may adversely impact EFH. They are grouped into four different systems in which the activities usually occur: upland, river or riverine, estuary or estuarine, and coastal or marine. Riverine habitats provide important habitat that serves multiple purposes for anadromous species such as salmon. These purposes include migration, feeding, spawning, nursery, and rearing functions. Protecting these functions is key to providing for a productive system and a healthy fishery. An important component of a river system also includes the riparian corridor. The term "riparian" refers to the land directly adjacent to a stream, lake, or estuary. A healthy riparian area has vegetation harboring prey items (e.g., insects), contributes necessary nutrients, provides large woody debris (LWD) that creates channel structure and cover for fish, and provides shade, which controls stream temperatures (Bilby and Ward 1991) . When vegetation is removed from riparian areas, waters are heated, and LWD is less common. This results in less refuge for fish, fundamental changes in channel structure (e.g., loss of pool habitats), instability of streambanks, and alteration of nutrient and prey sources within the river system.

Estuaries are the bays and inlets influenced by both the ocean and rivers, and they serve as the transition zone between fresh and salt water (Botkin et al. 1995). Estuaries support a community of plants and animals that are adapted to the zone where fresh and salt waters mix (Zedler et al. 1992). Estuarine habitats fulfill fish and wildlife needs for reproduction, feeding, refuge, and other physiological necessities (Simenstad et al. 1991, Good 1987, Phillips 1984). Healthy estuaries include eelgrass beds which protect young fish from predators, provide habitat for fish and wildlife, improve water quality, and control sediments (Thayer et al. 1984, Hoss and Thayer 1993, Phillips 1984). In addition, mud flats, high salt marsh, and saltmarsh creeks also provide productive shallow water habitat for epibenthic fishes and decapods (Sogard and Able 1991).

Coastal or marine habitats comprise a variety of broad habitat types for EFH managed species including sand bottoms, rocky reefs, and submarine canyons. When rock reefs support kelp stands, they become exceptionally productive. Relative to other habitats, including wetlands, shallow and deep sand bottoms, and rock bottom artificial reefs, giant kelp habitats are substantially more productive in the fish communities they support (Bond et al. 1999). Foster and Schiel (1985) reported that the net primary productivity of kelp beds may be the highest of any marine community. Lush kelp forest communities (e.g., giant kelp, bull kelp, elk kelp, and feather boa kelp) are found relatively close to shore along the open coast. These subtidal communities provide vertically structured habitat through the water column on the rocky shelf, made up of a canopy of tangled stipes from the water line to a depth of 10 feet; a mid-kelp, water-column region; and the bottom, holdfast region. The stands provide nurseries, feeding grounds, and/or shelter to a variety of groundfish species and their prey (Feder et al. 1974; Ebeling et al.

1980).

Non-fishing Impacts

The diversity, widespread distribution, and ecological linkages with other aquatic and terrestrial environments make the waters and substrates that comprise EFH susceptible to a wide array of human activities unrelated to fishing.

Non-fishing activities have the potential to adversely affect the quantity or quality of EFH designated areas in riverine, estuarine, and marine systems. Broad categories of such activities include, but are not limited to, mining, dredging, fill, impoundment, discharge, water diversions, thermal additions, actions that contribute to nonpoint source pollution and sedimentation, introduction of potentially hazardous materials, introduction of exotic species, and the conversion of aquatic habitat that may eliminate, diminish, or disrupt the functions of EFH.   For each activity, known and potential adverse impacts to EFH are described in this document. The descriptions explain the mechanisms or processes that may cause the adverse effects and how these may affect habitat function.

The report also provides proactive conservation measures designed to minimize or avoid the adverse effects of these non-fishing gear activities on Pacific coast EFH. These measures should be viewed as options to avoid, minimize, or compensate for adverse impacts and promote the conservation and enhancement of EFH. Generally, non-water-dependent actions should not be located in EFH if such actions may have adverse impacts on EFH. Activities that may result in significant adverse affects on EFH should be avoided where less environmentally harmful alternatives are available. If there are no alternatives, the impacts of these actions should be minimized. Environmentally sound engineering and management practices should be employed for all actions that may adversely affect EFH. If avoidance or minimization is not possible, or will not adequately protect EFH, compensatory mitigation to conserve and enhance EFH is recommended.

Purpose of Document

It is of paramount importance that NOAA Fisheries' biologists review proposed projects under the EFH provisions to ensure that they provide appropriate EFH conservation recommendations. It is equally challenging during the consultation phase to consider all potential non-fishing impacts to EFH so that the appropriate mix of recommendations can be made. Because impacts that may adversely affect EFH can be direct, indirect, and cumulative, the biologist must consider and analyze these interrelated impacts. Consequently, it is not unusual for particular impacts to be overlooked or the most recent science on impacts not to be considered during the consultation. This reference document was prepared to assist NOAA Fishery biologists in reviewing proposed projects and considering potential impacts that may adversely affect EFH and to provide consistent and substantiated EFH conservation recommendations. The document should also be useful for federal action agencies undertaking EFH consultations and especially in preparing EFH assessments.

The document is organized by activities that may potentially impact EFH occurring in four discreet ecosystems. The separation of these ecosystems is artificial, and many of the impacts and their related activities are not exclusive to one system. For instance, sand and gravel mining activities often occur in riverine systems but also take place in estuarine systems. Because activities are located in the ecosystem where they initially occur in a watershed progression, the reader is encouraged to rely on the index at the end of this document to verify other systems where such activities may also take place.   In addition, many types of impacts occur beyond just the primary activity. For example, pile driving creates its own set of unique impacts to EFH. However, while installing piles, other construction activities such as dredging may occur, and this secondary activity brings its own set of potential adverse impacts. Again, the biologist should rely on the index to ensure that all project activities are considered in the consultation.

The EFH conservation recommendations included with each activity present a series of site-specific measures that can be undertaken by the action agency to avoid, offset, or mitigate impacts to EFH. Not all of these suggested measures are necessarily applicable to any one project or activity that may adversely affect EFH. More specific or different measures based on the best and most current scientific information may be developed prior to, or during, the EFH consultation process and communicated to the appropriate agency. The conservation recommendations provided represent a short menu of general types of conservation actions that can contribute to the conservation and enhancement of properly functioning EFH.

2.0 UPLAND ACTIVITIES

2.1 Nonpoint Source Pollution

The information in this section is adapted from the following reference: EPA. 1993. Guidance for specifying management measures for sources of nonpoint pollution in coastal waters. EPA Office of Water. 840-B-92-002. 500+ pp.

Nonpoint source pollution generally results from land runoff, precipitation, atmospheric deposition, seepage, or hydrologic modification. Technically, the term ‘nonpoint source’ means anything that does not meet the legal definition of ‘point source’ in section 502(14) of the Clean Water Act, which refers to “discernable, confined and discrete conveyance” from which pollutants are or may be discharged. The major categories of nonpoint pollution are agricultural runoff, urban runoff, including developed and developing areas (see Section 2.2), silvicultural (forestry) runoff (see Section 2.1.2), marinas and recreational boating, road construction, and channel and streambank modifications, including channelization, channel modifications (see Section 4.7), and streambank and shoreline erosion.

Nonpoint source pollution is usually lower in intensity than an acute point source event, but may be more damaging to fish habitat in the long term. Nonpoint source pollution is often difficult to detect. It may affect sensitive life stages and processes, and the impacts may go unnoticed for a long time. When severe population impacts are finally noticed, they may not be tied to any one event and hence may be difficult to correct, clean up, or mediate.

2.1.1 Agricultural/Nursery Runoff

Substantial portions of croplands and commercial nursery operations are connected to inland and coastal waters where nonpoint pollution can have a direct adverse effect on aquatic habitats. Tillage aerates the upper soil, but compacts fine textured soils just below the depth of tillage, thus altering infiltration. Use of farm machinery on cropland and adjacent roads causes further compaction, reducing infiltration and increasing surface runoff. Agricultural lands are also characterized by poorly maintained dirt roads and ditches that, along with drains, route sediments, nutrients, and pesticides directly into surface waters. Natural channels filter and process pollutants. In many instances, roads, ditches and drains have replaced headwater streams, and these constructed systems deliver pollutants directly to surface waters (Larimore and Smith 1963).

Rangeland soils can also become compacted by livestock (Platts 1991, Heady and Child 1994) with similar effects on runoff. Compaction of rangelands generally increases with grazing intensity, although site-specific soil and vegetative conditions are important (Kauffman and Krueger 1984, Heady and Child 1994). Johnson (1992) reviewed studies related to grazing and hydrologic processes and concluded that heavy grazing nearly always decreases infiltration, reduces vegetative biomass, and increases bare soil. Primary runoff pollutants are nutrients, pesticides, sediment, salts, and animal wastes. Because the primary routes of pesticide transport to EFH include not only surface runoff events, but also direct application, aerial drift, and groundwater systems, pesticide contamination is addressed separately in Section 2.1.3.

<u>Potential Adverse Impacts</u>

Adverse impacts to EFH from agricultural and nursery runoff can result from 1) nutrient loading, 2) introduction of animal wastes, 3) erosion, and 4) sedimentation.

Nutrients are applied to agricultural land in several different forms and come from various sources, including commercial fertilizers, manure from animal production facilities (with bedding and other wastes added to the manure), municipal and industrial treatment plant effluent and sludge, legume and crop residues, irrigation water, and atmospheric deposition of nutrients such as nitrogen and sulfur. Specifically, nitrogen and phosphorus are the two major nutrients from agricultural land that degrade water quality. Introduction of these nutrients into aquatic systems can dramatically increase aquatic plant productivity and decay (cultural eutrophication; Waldichuk 1993). This process can increase turbidity, temperature, and the accumulation of dead organic material, and it can decrease light penetration, oxygen, and the growth of submerged aquatic vegetation. These alterations can result in the destruction of habitat for small or juvenile fish and severely impair biological food chains.

Animal waste (manure) includes fecal and urinary wastes of livestock and poultry; process water (such as from a milking parlor); and the feed, bedding, litter, and soil with which they become intermixed. Because riparian areas are favored by cattle, nutrients consumed elsewhere are often excreted as waste in riparian zones (Heady and Child 1994). Pollutants contained in manure and associated bedding materials can be transported into marine environments by runoff and process wastewater from rangelands, pastures, or confined animal facilities. Theses pollutants may include oxygen-demanding substances such as nitrogen, phosphorus, and organic solids; salts; bacteria, viruses, and other microorganisms, as well as sediments that increase organic decomposition. Runoff of animal wastes can cause fish kills due to ammonia, and solids deposited into the marine environment can reduce productivity over extended periods of time due to the accelerated effects of cultural eutrophication. Runoff can be accelerated by grazing processes that remove or disturb riparian vegetation and soils.

Sediment is the result of erosion. Sheet, rill, and gully erosion all transport fine sediment, enriched with a wide variety of attached pollutants, from agricultural land into the aquatic environment. The presence of livestock in the riparian zone accelerates sediment transport rates by increasing both surface erosion and mass wasting (Platts 1991, Marcus et al. 1990, Heady and Child 1994). Likewise, grazing in uplands can result in increased sediment delivery through channelized flows. For example, the Soil Conservation Service (SCS) estimated that 92 percent of the total sediment yields in the Snake and Walla Walla River basins of southeastern Washington resulted from sheet and rill erosion from cropland accounting for only 43 percent of total land area (SCS et al. 1984). Increased sediment in aquatic systems can increase turbidity, reduce light penetration, smother fish spawning areas and food supplies, clog the filtering capacity of filter feeders, clog and harm the gills of fish, interfere with feeding behaviors, and significantly lower overall biological productivity.

Salts are a product of natural weathering of soil and geologic material. The movement and deposition of salts depend on the amount and distribution of rainfall and irrigation, the soil and underlying strata, evapotranspiration rates, and other environmental factors. Irrigation water, whether from ground or surface water sources, has a natural base load of dissolved mineral salts. As water is consumed by plants or lost to the atmosphere by evaporation, the remaining salts become concentrated in the soil (the "concentrating effect"). Thus, the total salt load carried by irrigation return flow is the sum of the salts remaining in the applied water plus any additional salt picked up from the irrigated land. Irrigation return flows convey the salt to the receiving streams or groundwater reservoirs. If the amount of salt in the return flow is low in comparison to the total stream flow, water quality may not be degraded to the extent that EFH functions are impaired. However, if the process of water diversion and the return flow of saline drainage water is repeated many times along a stream or river, downstream habitat quality can become progressively degraded.

Groundwater is also susceptible to nutrient contamination in agricultural lands composed of sandy or other coarse-textured soil (Franco et al. 1994, USGS 1999). Nitrate, a highly soluble form of nitrogen, can leach rapidly through the soil profile and accumulate in groundwater, especially in shallow zones (Jordan and Weller 1996, Brady and Weil 1996). This groundwater can be a significant source of nutrients in surface waters when discharged through seeps, drains, or by direct subsurface flow to water bodies (Lee and Taylor 2000).

Recommended Conservation Measures

1. Protect and restore soil quality with controls that affect soil's ability to grow crops, partition and

regulate water flow, and act as an environmental filter (e.g., permeability, water holding capacity, nutrient availability, organic matter content, and biological activity). Relevant practices include cover cropping, crop sequence, conservation tillage, crop residue management, grazing management, and use of low-impact equipment (e.g., minimally sized, rubber tired).

2. Improve land use efficiencies for key agricultural inputs including nitrogen, phosphorus, pesticides, and irrigation water. Relevant practices are agronomic nutrient applications based upon nutrient testing, including manure, during clear weather, use of integrated pest management, and irrigation management.

3. Increase resistance to soil erosion and runoff. Sediment basins, contour farming, and grazing management are examples of key practices.

4. Protect and restore rangelands using practices such as rotational grazing systems or livestock distribution controls, exclusion from riparian and aquatic areas, livestock-specific erosion controls, reestablishment of vegetation, or extensive brush management correction.

5. Increase field and landscape buffers to provide cost-effective protection against the cumulative effects of many small, but unavoidable, pollutant discharges associated with an active agricultural enterprise and the kinds of catastrophic pollution that can be associated with the high energy flows and runoff associated with episodic storms. The full range of agricultural buffer practices (e.g., riparian forests, alley cropping, contour buffer strips, crosswind trap strips, field borders, filter strips, grassed waterways with vegetative filters, herbaceous wind barriers, vegetative barriers, and windbreak/shelterbelts) has to be systematically deployed, protected and managed across the agricultural landscape or overall aquatic habitat improvements will be minimal.

6. Optimize siting of new confined animal facilities or expansion of existing facilities by placing them away from riparian areas, surface water, and areas with high leaching potential to surface or groundwater. Ensure that adequate nutrient and wastewater collection facilities are in place. Ensure that sufficient cropland is available for agronomic application of animal wastes.

7. Consider using restored wetlands to reduce contamination from a variety of sources including nitrogen, phosphorus, suspended solids, biochemical oxygen demand (BOD), trace metals, trace organics, and pathogens. Larger wetland systems relative to the amount of land that is drained with longer retention times (at least 1 to 2 weeks) are most beneficial at improving water quality. Wetlands located within riparian buffer strips provide the most effective pollution removal by combining different treatment methods.

2.1.2 Silviculture/Timber Harvest

The harvest and cultivation of timber and other forestry products are major activities that can have both short- and long-term impacts throughout many coastal watersheds and estuaries. Timber harvest removes the dominant vegetation, converts mature and old-growth upland and riparian forests to tree stands or forests of early seral stage, reduces permeability of soils and increases the area of impervious surfaces, increases sedimentation from surface runoff and mass wasting processes, results in altered hydrologic regimes, and impairs fish passage through inadequate design, construction, and/or maintenance of stream crossings.

Deforestation associated with timber harvest can alter or impair instream habitat structure and watershed function. Timber harvest may result in inadequate or excessive surface and stream flows, increased stream bank and stream bed erosion, loss of complex instream habitats, sedimentation of riparian habitat, and increased surface runoff with associated contaminants (e.g., herbicides, fertilizers, fine sediments). Hydrologic characteristics, (e.g., water temperature, annual hydrograph) change, and greater variation in stream discharge is associated with timber harvest. Alterations in the supply of LWD and sediment can have negative effects on the formation and persistence of instream habitat features. Excess debris in the form of small wood and silt can smother benthic habitat and reduce dissolved oxygen levels.

Potential Adverse Impacts

Four major categories of activities can adversely affect EFH: 1) construction of logging roads, 2) creation of barriers, 3) removal of streamside vegetation, and 4) disturbance associated with log transfer facilities (LTFs) (see Section 4.9).

Logging road construction can destabilize slopes and increase erosion and sedimentation (see Road Building and Maintenance, Section 2.3). Two major types of erosion occur: mass wasting and surface erosion. Mass movement of soils, commonly referred to as landslides or debris slides, is associated with timber harvest and road building on high hazard soils and unstable slopes. Both frequency and size of debris slides are increased when logging roads are built on, or timber is harvested from, these unstable land forms. The result is increased erosion and sediment deposition in downslope waterways. Erosion from roadways is most severe when poor construction practices are employed that do not include properly located, sized, and installed culverts; proper ditching; and ditch blocker water bars (Furniss et al. 1991).

Stream crossings (bridges and culverts) on forest roads are often inadequately designed, installed, and maintained, and they frequently result in full or partial barriers to both the upstream and downsteam migration of adult and juvenile fish. Perched and undersized culverts can accelerate stream flows to the point that these structures become velocity barriers for migrating fish. Blocked culverts result from installation of undersized culverts or inadequate maintenance to remove debris. Blocked culverts can result in displacement of the stream from the downstream channel to the roadway or roadside ditch, resulting in dewatering of the downstream channel and increased erosion of the roadway. Culverts and bridges deteriorate structurally over time. Failure to replace or remove them at the end of their useful life may cause partial or total blockage of fish passage. Caution should be used, however, when removing culverts. Channel incision can often occur downstream of a culvert and generally moves upstream. An existing culvert can act as a grade control, halting the upstream progression of a headcut and causing further channel regrade (Castro 2003). The unchecked upstream progression of a headcut can cause further damage to EFH.

Removing streamside vegetation increases the amount of solar radiation reaching the stream and can result in warmer water temperatures, especially in small, shallow streams of low velocity. In southeast Alaska, Meehan et al. (1969) found that maximum temperature in logged streams without riparian buffers exceeded that of unlogged streams by up to 5ºC, but did not reach lethal temperatures. However, the increased water temperatures often exceeded optimum temperatures for pink and chum salmon (Reiser and Bjornn 1979). Logged streams have been associated with higher water temperatures, lower base flows and higher peak flows, and low oxygen levels that have resulted in significant mortalities of pink and chum salmon (Flanders and Cariello 2000). In cold climates, the removal of riparian vegetation can result in lower water temperatures during winter, increasing the formation of ice and damaging and delaying the development of incubating fish eggs and alevins.

By removing vegetation, timber harvest reduces transpiration losses from the landscape and decreases the absorptive capability of the groundcover. These changes result in increased surface runoff during periods of high precipitation and decreased base flows during dry periods. Reduced soil strength results in destabilized slopes and increased sediment and debris input to streams (Swanston 1974). Sediment deposition in streams can reduce benthic community production (Culp and Davies 1983), cause mortality of incubating salmon eggs and alevins, and reduce the amount of habitat available for juvenile salmon (Heifetz et al. 1996). Cumulative sedimentation from logging activities can significantly reduce the egg-to-fry survival of coho and chum salmon (Cederholm and Reid 1987, Myren and Ellis 1984.) Reductions in the supply of LWD also result when old-growth forests are removed, with resulting loss of habitat complexity that is critically important for successful salmonid spawning and rearing. (Bisson et al. 1988).

Recommended Conservation Measures

1. Set best management practices (BMPs) for impacts affecting particular habitats and resulting from specific types of silviculture-related activities provided in the “Additional Resources” section.

2. Avoid timber operations to the extent practicable near streams with EFH. For the Alaska region, see the following link: Fish: Forest-Wide Standards and Guides: http://www.fs.fed.us/r10/TLMP/F_PLAN/FPCHAP4.PDF; http://www.or.blm.gov/ForestPlan/newsandga.pdf

3. Avoid timber operations to the extent practicable in wetlands contiguous with anadromous fish streams. See the following link: Wetlands: Forest-Wide Standards and Guides: http://www.fs.fed.us/r10/TLMP/F_PLAN/FPCHAP4.PDF

4. Avoid timber operations to the extent practicable near estuary and beach habitats. See the following link: Beach and Estuary Fringe: Forest-Wide Standards and Guides: http://www.fs.fed.us/r10/TLMP/F_PLAN/FPCHAP4.PDF

5. Maintain riparian buffers along all streams. In the Alaska region, buffer width is site-specific and dependent on stream process type. Stream process groups are described in the following link: http://www.fs.fed.us/r10/TLMP/F_PLAN/APPEND_D.PDF. Standards and guidelines for riparian buffers for the Alaska region are described in the following link: Riparian: Forest-Wide Standards and Guides: http://www.fs.fed.us/r10/TLMP/F_PLAN/FPCHAP4.PDF .

6. Incorporate watershed analysis into timber and silviculture projects. Particular attention should be given to the cumulative effects of past, present, and future timber sales within the watershed. See the following link on watershed analysis: http://www.fs.fed.us/r10/TLMP/F_PLAN/APPEND_J.PDF

7. Follow BMPs. See the following link on BMPs: http://www.fs.fed.us/r10/TLMP/F_PLAN/APPEND_C.PDF

8. For forest roads, see Section 2.3, Road Building and Maintenance. For the Alaska region, also see the following links: 1) transportation: forest-wide standards and guides http://www.fs.fed.us/r10/TLMP/F_PLAN/FPCHAP4.PDF and 2) soils and water: forest-wide standards and guides: http://www.fs.fed.us/r10/TLMP/F_PLAN/FPCHAP4.PDF

2.1.3 Pesticide Application

More than 800 different pesticides are currently registered for use in the United States. Legal mandates covering pesticides are the Clean Water Act (CWA) and the Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA). Water quality criteria for the protection of aquatic life have only been developed for a few of the currently used chemicals (EPA, Office of Pesticide Programs). Collectively, these substances are designed to repel, kill, or regulate the growth of undesirable biological organisms. This diverse group includes fungicides, herbicides, insecticides, nematicides, molluscicides, rodenticides, fumigants, disinfectants, repellents, wood preservatives, and antifoulants. The most common pesticides are insecticides, herbicides, and fungicides. These are used for pest control on forested lands, agricultural crops, tree farms and nurseries, highways and utility rights of way, parks and golf courses, and residences. Pesticides can enter the aquatic environment as single chemicals or complex mixtures. Direct applications, surface runoff, spray drift, agricultural return flows, and groundwater intrusions are all examples of transport processes that deliver pesticides to aquatic ecosystems.

Pesticides are frequently detected in freshwater and estuarine systems that provide EFH. Nationwide, the most comprehensive environmental monitoring efforts have been conducted by the USGS as part of the National Water Quality Assessment (NAWQA) Program. A variety of human activities such as fire suppression on forested lands, forest site preparation, noxious weed control, right-of-way maintenance (roads, railroads, power lines, etc.), algae control in lakes and irrigation canals, various agricultural practices, riparian habitat restoration, and urban and residential pest control results in contamination from these substances. It is important to note that the term “pesticide” is a collective description of hundreds of chemicals with different sources, different fates in the aquatic environment, and different toxic effects on fish and other aquatic organisms. Despite these variations, all current use pesticides are 1) specifically designed to kill, repel, or regulate the growth of biological organisms and 2) intentionally released into the environment. Habitat alteration from pesticides is different from more conventional water quality parameters such as temperature, suspended solids, or dissolved oxygen because, unlike temperature or dissolved oxygen, the presence of pesticides can be difficult to detect due to limitation in proven methodologies. This monitoring may also be expensive. However, as analytical methodologies have improved in recent years, the number of pesticides documented in fish and their habitats has increased.

Potential Adverse Impacts

There are three basic ways that pesticides can adversely affect EFH. These are 1) a direct toxicological impact on the health or performance of exposed fish, 2) an indirect impairment of the productivity of aquatic ecosystems, and 3) a loss of aquatic vegetation that provides physical shelter for fish.

Fish kills are rare when pesticides are used according to their labels. For fish, the vast majority of effects from pesticide exposures are sublethal. Sublethal effects are a concern if they impair the physiological or behavioral performance of individual animals in ways that will decrease their growth or survival, alter migratory behavior, or reduce reproductive success. In addition to early development and growth, key physiological systems affected include the endocrine, immune, nervous, and reproductive systems. Many pesticides have been shown to impair one or more of these physiological processes in fish (Moore and Waring 2001). In general, however, the sublethal impacts of pesticides on fish health are poorly understood. Accordingly, this is a focus of recent and ongoing NOAA research (Scholz et al. 2000, Van Dolah et al. 1997).

The effects of pesticides on ecosystem structure and function can be a key factor in determining the cascading impacts of that chemical on fish and other aquatic organisms at higher trophic levels (Preston 2002). This includes impacts on primary producers (Hoagland et al. 1996) and aquatic microorganisms (DeLorenzo et al. 2001), as well as macroinvertebrates that are prey species for fish. For example, many pesticides are specifically designed to kill insects. Not surprisingly, these chemicals are relatively toxic to insects and crustaceans that inhabit river systems and estuaries. Overall, pesticides will have an adverse impact on fish habitat if they reduce the productivity of aquatic ecosystems. Finally, some herbicides are toxic to aquatic plants that provide shelter for various fish species. A loss of aquatic vegetation could damage nursery habitat or other sensitive habitats such as eelgrass beds and emergent marshes.

Recommended Conservation Measures

1. Incorporate integrated pest management (IPM) and BMPs as part of the authorization or permitting process to ensure the reduction of pesticide contamination in EFH (Scott et al. 1999).
2. Carefully review labels and ensure that application is consistent. Follow local, supplemental instructions such as county use bulletins where they are available.
3. Avoid the use of pesticides in and near EFH designated waters.
4. Refrain from areal spraying of pesticides on windy days.

2.2 Urban/Suburban Development

The information in this section is adapted from the following reference: NOAA Fisheries. 1998. Draft Document - Non-fishing threats and water quality: A reference for EFH consultation.

Urban growth and development in the United States continues to expand in coastal areas at a rate approximately four times greater than in other areas. The construction of urban, suburban, commercial, and industrial centers and corresponding infrastructure results in land use conversions typically resulting in vegetation removal and the creation of additional impervious surfaces. This runoff from impervious surfaces and storm sewers is the most widespread source of pollution into the Nation's waterways (EPA 1995).

Potential Adverse Impacts

Development activities within watersheds and in coastal marine areas often impact the EFH of managed species on both long-term and short-term scales. Many of the impacts listed here are discussed in greater detail in other sections of this documents. However, primary impacts include 1) the loss of riparian and shoreline habitat and vegetation and 2) runoff. The removal of upland and shoreline vegetation removal can increase stream water temperatures, reduce supplies of LWD, and reduce sources of prey and nutrients to the water system. An increase in impervious surfaces, such as the addition of new roads (see also Section 2.3), roofs, bridges, and parking facilities, results in a decreased infiltration to groundwater and increased runoff volumes. This also has the potential to adversely affect water quality and water quantity/timing in downstream water bodies (i.e. estuaries and coastal waters).

The loss of riparian and shoreline habitat and vegetation can increase water temperatures and remove sources of cover. Such impacts can alter the structure of benthic and fish communities, resulting in an expected reduction in diversity and abundance of EFH species. Shoreline stabilization projects (see Section 4.7) that affect reflective wave energy can impede or accelerate natural movements of shoreline substrates, thereby impacting intertidal and sub-tidal habitats. Channelization of rivers cause loss of floodplain connectivity and simplification of habitat. The resulting sediment runoff can also restrict tidal flows and tidal elevations, resulting in losses of important fauna and flora (e.g., submerged aquatic vegetation).

Due to the intermittent nature of rainfall and runoff, the large variety of pollutant source types, and the variable nature of source loadings, urban runoff is difficult to control (Safavi 1996). The National Water Quality Inventory (EPA 2002) reports that runoff from urban areas is the leading source of impairment to surveyed estuaries and the third largest source of impairment to surveyed lakes. These include construction sediments, oil from autos, bacteria from failing septic systems, road salts, and heavy metals. Urban areas have an insidious pollution potential that one-time events such as oil spills do not. Pollutant increases gradually result in gradual declines in habitat quality.

Storm drains are often built to move water quickly away from roads, resulting in increased water input to streams. This greater volume and velocity erodes streambanks, increasing sediment loads and often temperatures. In a simulation model comparing an urban watershed with a forested watershed, Corbett et al. (1997) demonstrated that urban runoff volume and sediment yield were 5.5 times greater than forest runoff.

Also waterborne polyaromatic hydrocarbon (PAH) levels have been found to be significantly higher in an urbanized watershed when compared to a non-urbanized watershed (Fulton et al. 1993). Petroleum-based contaminants (such as fuel, oil, and some hydraulic fluids) contain PAHs which can cause acute toxicity to EFH species and their prey at high levels of exposure and can also cause chronic lethal as well as acute and chronic sublethal toxicity (Neff 1985).

Failing septic systems are an outgrowth of urban development. EPA estimates that 10 to 25 percent of all individual septic systems are failing at any one time, introducing excrement, detergents, endocrine disruptors, and chlorine into the environment. Even treated wastewater from urban areas can alter the physiology of intertidal organisms (Moles, A. and N. Hale. in press). Sewage discharge is a major source of coastal pollution, contributing 41 percent, 16 percent, 41 percent, and 6 percent of the total pollutant load for nutrients, bacteria, oils and toxic metals, respectively (Kennish 1998). Nutrients such as phosphorus concentrations, in particular, are indicative of urban stormwater runoff (Holler 1990). Sewage wastes may also contain significant amounts of organic matter that exert a biochemical oxygen demand (Kennish 1998). Organic contamination contained within urban runoff can also cause immuno suppression (Arkoosh et al. 2000) (NOAA Fisheries Draft 1998).

Recommended Conservation Measures

See also Section 2.3, Recommended Conservation Measures for Roads.

1. Implement BMPs (EPA 1993) for sediment control during construction and maintenance operations. These can include avoiding ground disturbing activities during the wet season; minimizing exposure time of disturbed lands; using erosion prevention and sediment control methods; minimizing the spatial extent of vegetation disturbance; maintaining buffers of vegetation around wetlands, streams, and drainage ways; and avoiding building activities in areas of steep slopes and areas prone to mass wasting events with highly erodible soils. Use methods such as sediment ponds, sediment traps, bioswales, or other facilities designed to slow water runoff and trap sediment and nutrients.
2. Avoid using hard engineering structures for shoreline stabilization and channelization when possible. Use bioengineering approaches (i.e., using vegetation approaches with principles of geomorphology, ecology, and hydrology) to protect shorelines and river banks. Naturally stable shorelines and river banks should not be altered (see Section 4.7).
3. Encourage comprehensive planning for watershed protection so as to avoid filling and building in floodplain areas affecting EFH. Development sites should be planned to minimize clearing and grading, cut-and-fill, and new impervious surfaces.
4. Where feasible, remove impervious surfaces such as abandoned parking lots and buildings from riparian and shoreline areas, and reestablish wetlands and native vegetation.
5. Protect and restore vegetated buffer zones of appropriate width along all streams, lakes, and wetlands that include or influence EFH.
6. Manage stormwater to duplicate the natural hydrologic cycle, maintaining natural infiltration and runoff rates to the maximum extent practicable.
7. Where in-stream flows are insufficient to maintain water quality and quantity needed for EFH, establish conservation guidelines for water use permits and encourage the purchase or lease of water rights and the use of water to conserve or augment instream flows in accordance with state and federal water law.
8. Encourage municipalities to use the best available technologies in upgrading their wastewater systems to avoid combined sewer overflow problems and chlorinated sewage discharges into rivers, estuaries, and the ocean.
9. On-site disposal systems should be properly designed and installed. They should be located away from open waters, wetlands, and floodplains.

2.3 Road Building and Maintenance

The building and maintenance of roads can affect aquatic habitats by increasing rates of natural processes such as debris slides or landslides and sedimentation, introducing exotic species, and degrading water quality and chemical contamination (e.g., petroleum-based contaminants; see Section 2.2). Paved and dirt roads introduce an impervious or semi-pervious surface into the landscape. This surface intercepts rain and creates runoff carrying soil, sand and other sediments, and oil-based materials quickly downslope. If roads are built near streams, wetlands, or other sensitive areas, these may be affected by the increased sedimentation that occurs both from maintenance and use and during storm and snowmelt events. Even carefully designed and constructed roads can become sources of sediment and pollutants if they are not properly maintained.

<u>Potential Adverse Impacts</u>

The effects of roads on aquatic habitat can be profound and include 1) increased deposition of fine sediments, 2) changes in water temperature, 3) elimination or introduction of migration barriers such as culverts, 4) changes in streamflow, 5) introduction of non-native plant species, and 6) changes in channel configuration.

Poorly surfaced roads can substantially increase surface erosion, and the rate of erosion is primarily a function of storm intensity, surfacing material, road slope, and traffic levels. This surface erosion results in an increase in fine sediment deposition (Bilby et al. 1989, MacDonald et al. 2001, Ziegler et al. 2001). An increase of fine-sediment deposition in stream gravels has been linked to decreased fry emergence, decreased juvenile densities, loss of winter carrying capacity, and increased predation of fishes (Koski 1981). Increased sediment fines can reduce benthic production or alter the composition of the benthic community. For example, embryo-to-emergent fry survival of incubating salmonids is negatively affected by increases in fine sediments in spawning gravels (Chapman 1988, Everest et al. 1987, Scrivener and Brownlee 1989, Weaver and Fraley 1993, Young et al. 1991).

Roads built adjacent to streams result in changes in water temperature and increased sunlight reaching the stream as riparian vegetation is removed and/or altered in composition. Beschta et al. (1987) and Hicks et al. (1991) document some of the negative effects of road construction on fish habitat, including elevation of stream temperatures beyond the range of preferred rearing, inhibition of upstream migrations, increased disease susceptibility, reduced metabolic efficiency, and shifts in species assemblages.

Roads can also degrade aquatic habitat through improperly placed culverts at road-stream crossings that reduce or eliminate fish passage (Belford and Gould 1989, Clancy and Reichmuth 1990, Evans and Johnston 1980, Furniss et al. 1991). In a large river basin in Washington, 13 percent of the historical coho habitat was lost due to improper culvert design and placement. (Beechie et al. 1994). Road crossings also affect benthic communities of stream invertebrates. Roads have a negative effect on the biotic integrity of both terrestrial and aquatic ecosystems (Trombulak and Frissell 2000). Studies indicate that populations of non-insect invertebrates tend to increase the farther from a road they are measured (Luce and Crowe 2001).

Roads may be the first point of entry into a virgin landscape for non-native grass species that are seeded along road cuts or introduced from seeds transported by tires and shoes. Roads can serve as corridors for such species allowing plants to move further into the landscape (Greenberg et al. 1997, Lonsdale and Lane 1994). Some non-native plants may be able to move away from the roadside and into aquatic sites of suitable habitat, where they may out-compete native species and have significant biological and ecological effects on the structure and function of the ecosystem.

Roads have three primary effects on hydrologic processes. First, they intercept rainfall directly on the road surface, in road cutbanks, and as subsurface water moving down the hillslope. Second, they concentrate flow, either on the road surfaces or in adjacent ditches or channels. Last, they divert or reroute water from flowpaths that would otherwise be taken if the road were not present (Furniss et al. 1991).

Road drainage and transport of water and debris, especially during heavy rains and snow melt periods, are primary reasons why roads fail, often with major structural, ecological, economic, or other social consequences. The effects of roads on peak streamflow depend strongly on the size of the watershed and the density of roads. Some of the effects are 1) changes in flood flows (Wemple et al. 1996) but mainly in smaller basins and for smaller floods (Beschta et al. 2000), and 2) increased channel erosion and mass wasting (Montgomery 1994, Madej 2001, Wemple et al. 2001). For example, capture and rerouting of water can dewater one small stream and cause major channel adjustments in the stream receiving the additional water. In large watersheds with low road density, properly located and maintained roads may constitute a small proportion of the land surface and have relatively insignificant effects on peak flow.

Roads can lead to increased rates of natural processes such as debris or landslides and sedimentation when slopes are destabilized and surface erosion and soil mass movement increases. Erosion is most severe when poor construction practices are allowed, combined with inadequate attention to proper road drainage and maintenance practices. Mass movement risks increase when roads are constructed on high-hazard soils and overly steep slopes. In steep areas prone to landslides, rates of mass soil movements affected by roads include shallow debris slides, deep-seated slumps and earthflows, and debris flows. Accelerated erosion rates from roads because of debris slides range from 30 to 300 times the natural rate in forested areas, but vary with terrain in the Pacific Northwest (Sidle et al. 1985). The magnitude of road-related mass erosion varies by climate, geology, road age, construction practices, and storm history. Road-related mass failures result from various causes, including improper placement and construction of road fills and stream crossings; inadequate culvert sizes to pass water, sediment, and wood during floods; poor road siting; modification of surface or subsurface drainage by the road surface or prism; and diversion of water into unstable parts of the landscape (Burroughs et al. 1976, Clayton 1983, Hammond et al. 1988, Furniss et al. 1991, Larsen and Parks 1997).

Recommended Conservation Measures

1. Avoid locating roads near fish-bearing streams. Roads should be sited to avoid sensitive areas such as streams, wetlands, and steep slopes.
2. Incorporate erosion control and stabilization measures into road construction plans to reduce erosion potential.
3. Build bridges when possible. If culverts are to be used, they should be sized, constructed, and maintained to match the gradient and width of the stream, so as to accommodate 100-year flood flows, but equally to provide for migratory passage of adult and juvenile fishes. Utilize guidelines provided in the document: "Guidelines for Salmonid Passage at Stream Crossing," NOAA Fisheries, Southwest Region, October 2001 (http://swr.nmfs.noaa.gov/hcd/NMFSSCG.PDF).
4. Locate stream crossings in stable stream reaches.
5. Design bridge abutments to minimize disturbances to streambanks and place abutments outside of the floodplain whenever possible.
6. Avoid road construction across alluvial floodplains, mass wastage areas, or braided stream bottom lands unless site-specific protection can be implemented to ensure protection of soils, water, and associated resources.
7. Avoid side-casting of road materials into streams year-round.
8. Use only native vegetation in stabilization plantings.
9. Maintenance practices should not cause existing problems to worsen.

3.0 RIVERINE ACTIVITIES

3.1 Mining (see Section 5.6 - Marine Mining)

Mining and mineral extraction activities take many forms such as commercial dredging and recreational suction dredging, placer, area surface removal, and contour operations. Activities include exploration, site preparation, mining, milling, waste management, decommissioning or reclamation, and even mine abandonment (American Fisheries Society [AFS] 2000). Mining and its associated activities have the potential to cause environmental impacts from exploration through post-closure. These impacts may include adverse effects to EFH. The operation of metal, coal, rock quarries, and gravel pit mining has caused varying degrees of environmental damage in urban, suburban, and rural areas. Some of the most severe damage, however, occurs in remote areas, where some of the most productive fish habitat is often located (Sengupta 1993). Regulations have been designed to control and manage these changes to the landscape to avoid and minimize impacts. These regulations are updated as new technologies are developed to improve mineral extraction, reclaim mined lands, and limit environmental impacts. However, while environmental regulations may avoid, limit, control, or offset many of these potential impacts, mining will, to some degree, always alter landscapes and environmental resources (National Research Council [NRC] 1999).

3.1.1 Mineral Mining

<u>Potential Adverse Impacts</u>

Potential impacts from mining include 1) adverse modification of hydrologic conditions so as to cause erosion of desirable habitats, 2) removal of substrates that serve as habitat for fish and invertebrates, 3) conversion of habitats, 4) release of harmful or toxic materials, and 5) creation of harmful turbidity levels.

The effects of mineral mining on EFH depend on the type, extent, and location of the activities. Minerals are extracted using several methods. Surface mining involves suction dredging, hydraulic mining, panning, sluicing, strip mining, and open-pit mining (including heap leach mining). Underground mining uses tunnels or shafts to extract minerals by physical or chemical means. Surface mining probably has a greater potential to affect aquatic ecosystems, though specific effects will depend on the extraction and processing methods and the degree of disturbance (Spence et al. 1996). Surface mining has the potential to eliminate vegetation, permanently alter topography, permanently and drastically alter soil and subsurface geological structure, and disrupt surface and subsurface hydrologic regimes (AFS 2000). While mining may not be as geographically pervasive as other sediment-producing activities, surface mining typically increases sediment delivery much more per unit of disturbed area than other activities because of the level of disruption of soils, topography, and vegetation. Erosion from surface mining and spoils may be one of the greatest threats to salmonid habitats in the western United States (Nelson et al. 1991).

Mining and placement of spoils in riparian areas can cause the loss of riparian vegetation and changes in heat exchange, leading to higher summer temperatures and lower winter stream temperatures (Spence et al. 1996). Bank instability can also lead to altered width-to-depth ratios, which further influence temperature (Spence et al. 1996). Mining efforts can also bury productive habitats near mine sites.

Mining operations can release harmful or toxic materials and their byproducts, either in association with actual mining, or in connection with machinery and materials used for mining. Mining can also introduce levels of heavy metals and arsenic that are naturally found within the stream bed sediments. Tailings and discharge waters from settling ponds can result in loss of EFH and life stages of managed species. The impact degrades water quality and levels can become high enough to prove lethal (North Pacific Fishery

Management Council [NPFMC] 1999).

Commercial operations may also involve road building (see Section 2.3), tailings disposal (Section 4.2), and leaching of extraction chemicals, all of which may create serious impacts to EFH. Cyanide, sulfuric acid, arsenic, mercury, heavy metals, and reagents associated with such development are a threat to EFH. Improper or in-water disposal of tailings may be toxic to managed species or their prey downstream. Upland disposal of tailings in unstable or landslide prone areas can cause large quantities of toxic compounds to be released into streams or to contaminate groundwater (NPFMC 1999). Indirectly, the sodium cyanide solution used in heap leach mining is contained in settling ponds from which groundwater and surface waters may become contaminated (Nelson et al. 1991).

Water pollution by heavy metals and acid is also often associated with mineral mining operations, as ores rich in sulfides are commonly mined for gold, silver, copper, iron, zinc, and lead. When stormwater comes in contact with sulfide ores, sulfuric acid is commonly produced (West et al. 1995). Abandoned pit mines can also cause severe water pollution problems.

Recreational gold mining with such equipment as pans, motorized or nonmotorized sluice boxes, concentrators, rockerboxes, and dredges can adversely affect EFH on a local level. Commercial mining is likely to involve activities at a larger scale with much disturbance and movement of the channel involved (OWRRI 1995).

Recommended Conservation Measures

The following suggested measures are adapted from recommendations in Spence et al. (1996), NMFS (1996), and Washington Department of Fish and Wildlife (WDFW) (1998).

1. Avoid mineral mining in waters and streams containing EFH.
2. Schedule necessary in-water activities when the fewest species/least vulnerable life stages of federally managed species will be present.
3. Use an integrated environmental assessment, management, and monitoring package in accordance with state and federal law. Allow for adaptive operations to minimize adverse effects on EFH.
4. Avoid spills of dirt, fuel, oil, toxic materials, and other contaminants into EFH. Prepare a spill prevention plan and maintain appropriate spill containment and water repellent/oil absorbent cleanup materials on hand.
5. Treat wastewater (acid neutralization, sulfide precipitation, reverse osmosis, electrochemical, or biological treatments) and recycle on site to minimize discharge to streams. Test wastewater before discharge for compliance with federal and state clean water standards.
6. Minimize opportunities for sediments to enter or affect EFH. Use methods such as contouring, mulching, and construction of settling ponds to control sediment transport. Monitor turbidity during operations, and cease operations if turbidity exceeds predetermined threshold levels. Use turbidity/sediment curtains to limit the spread of suspended sediments and minimize the area affected.
7. Reclaim, rather than bury, mine waste that contains heavy metals, acid materials, or other toxic compounds if leachate can enter EFH through groundwater.
8. Restore natural contours and plant native vegetation on site after use to restore habitat function to the extent practicable. Monitor the site for an appropriate period of time to evaluate performance and implement corrective measures if necessary.
9. Minimize the aerial extent of ground disturbance (e.g., through phasing of operations), and stabilize disturbed lands to reduce erosion.

3.1.2 Sand and Gravel Mining

Potential Adverse Impacts

Mining of sand and gravel is extensive and occurs by several methods. These include wet-pit mining (i.e., remove material from below the water table), dry-pit mining on beaches, exposed bars and ephemeral streambeds, and subtidal mining. Sand and gravel mining in riverine, estuarine, and coastal environments can create EFH impacts including 1) turbidity plumes and resuspension effects, 2) removal of spawning habitat, and 3) alteration of channel morphology.

Mechanical disturbance of EFH spawning habitat by mining equipment can also lead to high mortality rates in early life stages. One result is the creation of turbidity plumes (Section 4.1) which can move several kilometers downstream. Sand and gravel mining in riverine, estuarine, and coastal environments can also suspend materials at the sites (Section 5).

Sedimentation may be a delayed effect, because gravel removal typically occurs at low flow when the stream has the least capacity to transport fine sediments out of the system. Another delayed sedimentation effect results when freshets inundate extraction areas that are less stable than before. In addition, for species such as salmon, gravel operations can also interfere with migration past the site if they create physical or thermal changes at the work site or downstream from the site (OWRRI 1995).

Additionally, extraction of sand and gravel in riverine ecosystems can directly eliminate the amount of gravel available for spawning if the extraction rate exceeds the deposition rate of new gravel in the system. Gravel excavation also locally reduces the supply of gravel to downstream habitats. The extent of suitable spawning habitat may be reduced where degradation reduces gravel depth or exposes bedrock (Spence et al. 1996).

Mining can also alter channel morphology by making the stream channel wider and shallower. Consequently, the suitability of stream reaches as rearing EFH may be decreased, especially during summer low-flow periods when deeper waters are important for survival. Similarly, a reduction in pool frequency may adversely affect migrating adults that require holding pools (Spence et al. 1996). Changes in the frequency and extent of bedload movement and increased erosion and turbidity can also remove spawning substrates, scour redds (resulting in a direct loss of eggs and young), or reduce their quality by deposition of increased amounts of fine sediments. Other effects that may result from sand and gravel mining include increased temperatures (from reduction in summer base flows and decreases in riparian vegetation), decreased nutrients (from loss of floodplain connection and riparian vegetation), and decreased food production (loss of invertebrates) (Spence et al. 1996).

Examples of using gravel removal to improve habitat and water quality are limited and isolated (OWRRI 1995). Deep pools created by material removal in streams appear to attract migrating adult salmon for holding. These concentrations of fish may result in high losses as a result of increase in predation or recreational fishing pressure.

<u>Recommended Conservation Measures</u>

The following suggested measures are adapted from NMFS (1996) and OWRRI (1995).

1. Avoid sand/gravel mining in waters containing EFH. Many factors influence site selection for a gravel or sand mining site. Because of the need to incorporate technical, economic and environmental factors, siting decisions should be considered on a case-by-case basis (USFWS 1980).
2. Identify upland or off-channel (where channel will not be captured) gravel extraction sites as alternatives to gravel mining in or adjacent to EFH, if possible.
3. Design, manage, and monitor sand and gravel mining operations to minimize potential direct and indirect impacts to EFH if operations in EFH cannot be avoided. This includes, but is not limited to, migratory corridors, foraging and spawning areas, stream/river banks, intertidal areas, etc.
4. Minimize the areal extent and depth of extraction.
5. Include restoration, mitigation, and monitoring plans in sand/gravel extraction plans.

3.2 Debris Removal

3.2.1 Organic Debris

Natural occurring flotsam such as LWD and macrophyte wrack (i.e., kelp) is often removed from streams, estuaries, and coastal shores. This debris is removed for a variety of reasons including dam operations, aesthetic concerns, and commercial and recreational uses. Because the debris affects habitat function and provides habitat for aquatic and terrestrial organisms, removing it may change the ecological balance among riverine, estuarine, and coastal ecosystems.

Potential Adverse Impacts

LWD and macrophyte wrack promote habitat complexity and structure to various aquatic and shoreline habitats. The structure provides cover for managed species, creates habitats and microhabitats (e.g., pools, riffles, undercut banks, side channels), and retains gravels and can maintain the underlying channel structure (Abbe and Montgomery 1996, Montgomery et al. 1995, Ralph et al. 1994, Spence et al. 1996) in riverine systems. Its removal reduces these habitat functions. Reductions in LWD input to estuaries have reduced the spatially complex and diverse channel systems that provide for productive salmon habitat (NRC 1996). Woody debris also plays a significant role in salt marsh ecology (Maser and Sedell 1994). Reductions in woody debris input to the estuaries may affect the ecological balance of the estuary. LWD also plays a significant role in benthic ocean ecology, where deep-sea wood borers convert the wood to fecal matter, providing terrestrial based carbon to the ocean food chain (Maser and Sedell 1994). Dams and commercial in-river harvest of large woody debris have dwindled the supply of wood, jeopardizing the ecological link between the forest and the sea (Collins et al. 2002, Collins et al. 2003, Maser and Sedell 1994).

Species richness, abundance, and biomass of macrofauna (e.g., sand crabs, isopods, amphipods and polychaetes) associated with beach wrack are higher compared to beach areas with lower amounts of wrack or that are groomed(Dugan et al. 2000). The input and maintenance of wrack can strongly influence the structure of macrofauna communities including the abundance of sand crabs (*Emerita analoga)* (Dugan et al. 2000), an important prey species to some EFH managed species. Beach grooming can substantially alter the macrofaunal community structure of exposed sand beaches (Dugan et al. 2000). In addition, there are concerns that beach grooming efforts to remove wrack may also harm the eggs of the grunion (*Leuresthes tenuis*), an important prey item of EFH managed species.

Recommended Conservation Measures

1. Remove woody debris only when it presents a threat to life or property. Leave LWD wherever possible. Reposition, rather than remove woody debris that must be moved.
2. Encourage appropriate federal, state, and local agencies to prohibit or minimize commercial removal of woody debris from rivers, estuaries, and beaches.
3. Encourage appropriate federal, state, and local agencies to aid in the downstream movement of LWD around dams, rather than removing it from the system.
4. Educate landowners and recreationalists about the benefits of maintaining LWD.
5. Localize beach grooming practices and minimize it whenever possible.
6. Conduct beach grooming only above the semilunar high tide as soon as the grunion spawning period begins in the spring, and continue 2 weeks after the last grunion spawning runs are observed in the summer.
7. Familiarize beach maintenance staff with the importance of such practices.

3.2.2 Inorganic Debris

Marine debris is a problem along much of U.S. coastal waters, littering shorelines, fouling estuaries, and creating hazards in the open ocean. Marine debris consists of a huge variety of man-made materials such as general litter, dredged materials, hazardous wastes, and discarded or lost fishing gear. It enters waterways either indirectly through rivers and storm drains or by direct ocean dumping. Marine debris can have serious negative effects on EFH. Although several legislative laws and regulatory programs exist to prevent or control the problem, marine debris continues to severely impact our waters.

Congress has passed numerous legislative acts intended to prevent the disposal of marine debris in U.S. ocean waters. These include the Marine Protection, Research, and Sanctuaries Act, Titles I and II (also known as the Ocean Dumping Act), The Federal Water Pollution Control Act (Clean Water Act), and the Comprehensive Environmental Response, Compensation, and Liability Act. The International Convention for the Prevention of Pollution from Ships, commonly known as MARPOL Annex V (33 CFR 151), is intended to protect the marine environment from various types of garbage by preventing ocean dumping if the ship is less than 25 nautical miles from shore. Dumping of unground food waste and other garbage is prohibited within 12 nautical miles from shore, and ground non-plastic or food waste may not be dumped within 3 nautical miles of shore. The Ocean Dumping Act implements the Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter (London Dumping Convention) for the United States. Section 311 of the Federal Water Pollution Control Act makes it unlawful for any person to discharge any pollutant into the waters of the United States except as authorized by law. The Comprehensive Environmental Response, Compensation, and Liability Act stipulates that releases of hazardous substances in reportable quantities must be reported, and the release must be removed by the responsible party. Regulations implementing these acts are intended to control marine debris from ocean sources, including galley waste and other trash from ships, recreational boaters and fishermen, and offshore oil and gas exploration and facilities.

Land-based sources of marine debris account for about 80 percent of the marine debris on beaches and in our waters. Debris from these sources can originate from combined sewer overflows and storm drains, storm-water runoff, landfills, solid waste disposal, poorly maintained garbage bins, floating structures, and general littering of beaches, rivers and open waters. Typical debris from these land-based sources includes raw or partially treated sewage, litter, hazardous materials, and discarded trash. Legislation and programs that address these land-based sources of pollution include the BEACH Act, the National Marine Debris Monitoring Program (NMDMP), the Shore Protection Act of 1989, and the Clean Water Act. The BEACH Act authorizes the EPA to fund state, territorial, Tribal, and local government programs that test and monitor coastal recreational waters near public access sites for microbial contaminants and to assess and monitor floatable debris. The NMDMP is a 5-year study designed to provide statistically valid estimates of marine debris affecting the entire U.S. coastline and to determine the main sources of the debris. The Shore Protection Act contains provisions to ensure that municipal and commercial solid wastes are not deposited in coastal waters during vessel transport from source to the waste receiving station. The Clean Water Act requires the EPA to develop and enforce regulations that treat storm water and combined sewer overflows as point source discharges requiring National Pollution Discharge Elimination System (NPDES) permits that prohibit non-storm water discharges into storm sewers.

<u>Potential Adverse Impacts</u>

Land- and ocean-based marine debris is a very diverse problem and adverse effects to EFH are likewise diverse. Floating or suspended trash can directly affect fish who consume or are entangled in the debris. Toxic substances in plastics can kill or impair fish and invertebrates that use habitat polluted by these materials which persist in the environment and can bioaccumulate through the food web. Once floatable debris settles to the bottom of estuaries, coastal, and open ocean areas, it may continue to cause environmental problems. Plastics and other materials with a large surface area can cover and suffocate immobile animals and plants, creating large spaces devoid of life. Currents can carry suspended debris to underwater reef habitats where the debris can become snagged, damaging these sensitive habitats. The typical floatable debris from combined sewer overflows includes street litter, sewage containing viral and bacterial pathogens, pharmaceutical by-products from human excretion, and pet wastes. It may contain condoms, tampons, and contaminated hypodermic syringes, all of which can pose physical and biological threats to EFH. Suspended organic matter has a high biological oxygen demand, and its reduction can cause algal blooms and anoxia that are detrimental to productive marine habitats. Pathogens can also contaminate shellfish beds.

<u>Recommended Conservation Measures</u>

1. Encourage proper trash disposal in coastal and ocean settings.
2. Advocate and participate in coastal cleanup activities.
3. Encourage enforcement of regulations addressing marine debris pollution and proper disposal.
4. Provide resources and technical guidance for development of studies and solutions addressing the

problem of marine debris.
5. Provide resources to the public on the impact of marine debris and guidance on how to reduce or eliminate the problem.

3.3 Dam Operation

The construction and operation of dams provide a source of hydropower, a reservoir for water storage, and a means to control flood control. Their operation, however, can affect water quality and quantity in riverine systems.

<u>Potential Adverse Impacts</u>

The effects of dam construction and operation on EFH can include 1) migratory impediments, 2) water flow and current pattern shifts, 3) thermal impacts, and 4) limits on sediment and woody debris transport.

One of the major impacts from dam construction and operation is that it impedes or completely creates impassable barriers to anadromous fish migrations in streams and rivers. Unless proper fish passage devices are in place, dams can either prevent access to productive upstream spawning habitat upstream or can alter downstream juvenile movements. The passage of salmon through turbines, sluiceways, bypass systems, and fish ladders also affects the quality of EFH (Pacific Fishery Management Council [PFMC] 1999).

In addition, dam operations also reduce downstream water velocities and change current patterns (PFMC 1999). These modifications can increase migration times (Raymond 1979). Water-level fluctuations, altered seasonal and daily flow regimes, reduced water velocities, and discharge volumes can affect the migratory behavior of juvenile salmonids and reduce the availability of shelter and foraging habitat (PFMC 1999).

Dams can also affect the thermal regimes of streams by raising water temperatures. Changes in water temperature can affect the development and smoltification of salmonids (PFMC 1999) and adult migration (Spence et al. 1996).

Dams also limit or alter natural sediment and LWD transport processes by impeding the high flows needed to scour fine sediments and move woody debris downstream (PFMC 1999). Curtailing these resources will affect the availability of spawning gravels and change channel morphology (Spence et al. 1996).

<u>Recommended Conservation Measures (Adapted from PFMC 1999)</u>

1. Operate facilities to create flow conditions that provide for passage, water quality, proper timing of life history stages, and properly functioning channel conditions, and to avoid strandings and redd dewatering.
2. Develop water and energy conservation guidelines for integration into dam operation plans and into regional and watershed-based water resource plans.
3. Provide mitigation (including monitoring and evaluation) for nonavoidable adverse effects on EFH.

3.4 Commercial and Domestic Water Use

Commercial and domestic water use demands to support the needs of homes, farms, and industries require a constant supply of water. Freshwater is diverted directly from lakes, streams, and rivers by means of pumping facilities or is stored in impoundments. Because human populations are expected to continue increasing along most of the West Coast, it is reasonable to assume that water uses, including water impoundments and diversion, will similarly increase (Gregory and Bisson 1997).

<u>Potential Adverse Impacts</u>

The information in this section is adapted from the following reference: NOAA Fisheries. 1998. Draft

Document - Non-fishing threats and water quality: A reference for EFH consultation.

The withdrawal of water can affect EFH by 1) altering natural flows and the process associated with flow rates, 2) affecting shoreline riparian habitats, 3) affecting prey bases, 4) affecting water quality, and 5) entraping fishes. Water diversions can involve either withdrawals, thus reducing flow, or discharges, thus increasing flow. Water withdrawal will alter natural flow and stream velocity and channel depth and width. It can also change sediment and nutrient transport characteristics (Christie et al. 1993, Fajen and Layzer 1993), increase deposition of sediments, reduce depth, and accentuate diel temperature patterns (Zale et al. 1993). Loss of vegetation along stream banks and coastlines due to fluctuating water levels can decrease the availability of fish cover and reduce stability (Christie et al. 1993). Changes in the quantity and timing of stream flow alters the velocity of streams, which, in turn, affects the composition and abundance of both insect and fish populations (Spence et al. 1996). Returning irrigation water to a stream, lake, or estuary can substantially alter and degrade habitat (NRC 1989). Problems associated with return flows include increased water temperature, increased salinity, introduction of pathogens, decreased dissolved oxygen, increased toxic contaminants from pesticides and fertilizers, and increased sedimentation (NPPC 1986). Diversions can also physically divert or entrap EFH managed species (see Section 5.3).

<u>Recommended Conservation Measures</u>

1. Design projects to create flow conditions adequate to provide for passage, water quality, proper timing of life history stages, and avoidance of juvenile stranding and redd dewatering, as well as to maintain and restore properly functioning channel, floodplain, riparian, and estuarine conditions.
2. Establish adequate instream flow conditions for anadromous fish.
3. Screen water diversions on fish-bearing streams, as needed.
4. Incorporate juvenile and adult fish passage facilities on all water diversion projects (e.g., fish bypass systems).
5. Ensure that mitigation is provided for non-avoidable impacts.

4.0 ESTUARINE ACTIVITIES

4.1 Dredging

Dredging navigable waters is a continuous impact primarily affecting benthic and water-column habitats in the course of constructing and operating marinas, harbors, and ports. Routine dredging, that is, the excavation of soft bottom substrates, is used to create deepwater navigable channels or to maintain existing channels that periodically fill with sediments. In addition, port expansion has become an almost continuous process due to economic growth, competition between ports, and significant increases in vessel size (see Section 4.3). Elimination or degradation of aquatic and upland habitats is commonplace since port expansion almost always affects open water, submerged bottoms, and, possibly, riparian zones.

Potential Adverse Impacts

The environmental effects of dredging on EFH can include 1) direct removal/burial of organisms; 2) turbidity/siltation effects, including light attenuation from turbidity; 3) contaminant release and uptake, including nutrients, metals, and organics; 4) release of oxygen consuming substances; 5) entrainment; 6) noise disturbances; and 6) alteration to hydrodynamic regimes and physical habitat.

Many EFH species forage on infaunal and bottom-dwelling organisms. Dredging may adversely affect these prey species at the site by directly removing or burying immobile invertebrates such as polychaete worms, crustacean, and other EFH prey types (Newell et al. 1998, Van der Veer et al. 1985). Similarly, the dredging activity may also force mobile animals such as fish to migrate out of the project area. Recolonization studies suggest that recovery may not be quite as straightforward. Physical factors including particle size distribution, currents, and compaction/stabilization processes following deposition reportedly can regulate recovery after dredging events. Rates of recovery listed in the literature range from several months for estuarine muds to up to 2 to 3 years for sands and gravels. Recolonization can also take up to 1 to 3 years in areas of strong current but up to 5 to 10 years in areas of low current. Thus, forage resources for benthic feeders may be substantially reduced.

The use of certain types of dredging equipment can result in greatly elevated levels of fine-grained mineral particles or suspended sediment concentration (SSC), usually smaller than silt, and organic particles in the water column. The associated turbidity plumes of suspended particulates may reduce light penetration and lower the rate of photosynthesis for subaquatic vegetation (Dennison 1987) and the primary productivity of an aquatic area if suspended for extended periods of times (Cloern 1987). If suspended sediments loads remain high, fish may suffer reduced feeding ability (Benfield and Minello 1996) and be prone to fish gill injury (Nightingale and Simenstad 2001a).

Sensitive habitats such as submerged aquatic vegetation beds, which provide food and shelter also may be damaged. Eelgrass beds are critical to nearshore food web dynamics (Wyllie-Echeverria and Phillips 1994, Murphy et al. 2000). Studies have shown seagrass beds to be among the areas of highest primary productivity in the world (Herke and Rogers 1993, Hoss and Thayer 1993). This primary production, combined with other nutrients, provide high rates of secondary production in the form of fish (Herke and Rogers 1993, Good 1987, Sogard and Able 1991).

The contents of the suspended material may react with the dissolved oxygen in the water and result in short-term oxygen depletion to aquatic resources (Nightingale and Simenstad 2001a). Dredging can also disturb aquatic habitats by resuspending bottom sediments and, thereby, recirculate toxic metals (e.g., lead, zinc, mercury, cadmium, copper etc.), hydrocarbons (e.g., polyaromatics) hydrophobic organics (e.g., dioxins), pesticides, pathogens, and nutrients into the water column (EPA 2000). Toxic metals and organics, pathogens, and viruses, absorbed or adsorbed to fine-grained particulates in the material, may become biologically available to organisms either in the water column or through food chain processes.

Direct uptake of fish species by hydraulic dredging at the proposed borrow site is also an issue. Definitive information in the literature shows that elicit avoidance responses to the suction dredge entrainment occurs for both benthic and water column oriented species (Larson and Moehl 1990, McGraw and Armstrong 1990).

Dredging, as well as the equipment used in the process such as pipelines (see Section 4.10), may damage or destroy spawning, nursery, and other sensitive habitats such as emergent marshes and subaquatic vegetation, including eelgrass beds and kelp beds. Dredging may also modify current patterns and water circulation of the habitat by changing the direction or velocity of water flow, water circulation, or dimensions of the water body traditionally used by fish for food, shelter, or reproductive purposes.

Recommended Conservation Measures

1. Avoid new dredging to the maximum extent practicable. Activities that would likely require dredging (such as placement of piers, docks, marinas, etc.) should, instead, be sited in deep water areas or designed to alleviate the need for maintenance dredging. Projects should be permitted only for water dependent purposes and only when no feasible alternatives are available.
2. Incorporate adequate control measures to minimize turbidity where the dredging equipment used is expected to create significant turbidity.
3. Undertake multi-season, pre-, and post-dredging biological surveys to assess impacts to animal and submerged aquatic vegetation communities.
4. Provide appropriate compensation for significant impacts (short-term, long-term and cumulative) to benthic environments resulting from dredging.
5. Perform dredging during the time frame when impacts due to entrainment of EFH managed species or their prey are least likely to be entrained. Dredging should be avoided in areas with submerged aquatic vegetation.
6. Reference all dredging latitude-longitude coordinates at the site so that information can be incorporated into a geographical information system (GIS) format. Inclusion of aerial photos may be useful to identify precise locations for long-term evaluation.
7. Test sediments for contaminants as per EPA and USACE requirements.
8. Address cumulative impacts of past and current dredging operations on EFH by considering them as part of the permitting process.
9. Identify excess sedimentation in the watershed that prompts excessive maintenance dredging activities and implement appropriate management techniques to ensure that actions are taken to curtail those causes.
10. Ensure that bankward slopes of the dredged area are slanted to acceptable side slopes (e.g., 3:1) to ensure that sloughing does not occur.
11. Avoid placing pipelines and accessory equipment used in conjunction with dredging operations to the maximum extent possible close to kelp beds, eelgrass beds, estuarine/salt marshes, and other high value habitat areas.

4.2 Disposal/Landfills

The discharge of dredged materials subsequent to dredging operations or the use of fill material in the construction/development of harbors results in sediments (e.g., dirt, sand, mud) covering or smothering existing submerged substrates. Usually these covered sediments are of a soft-bottom nature as opposed to rock or hard-bottom substrates.

4.2.1 Disposal of Dredged Material

Potential Adverse Impacts

The disposal of dredged material can adversely affect EFH by 1) impacting or destroying benthic communities, 2) affecting adjacent habitats; 3) creating turbidity plumes and introducing contaminants and/or nutrients.

Disposing dredged materials result in varying degrees of change in the physical, chemical, and biological characteristics of the substrate. Discharges may adversely affect infaunal and bottom-dwelling organisms at the site by smothering immobile organisms (e.g., prey invertebrate species) or forcing mobile animals (e.g., benthic-oriented fish species) to migrate from the area. Infaunal invertebrate plants and animals present prior to a discharge are unlikely to recolonize if the composition of the discharged material is drastically different.

Erosion, slumping, or lateral displacement of surrounding bottom of such deposits can also adversely affect substrate outside the perimeter of the disposal site by changing or destroying benthic habitat. The bulk and composition of the discharged material and the location, method, and timing of discharges may all influence the degree of impact on the substrate.

The discharge of material can result in greatly elevated levels of fine-grained mineral particles, usually smaller than silt, and organic particles in the water column (i.e., turbidity plumes). These suspended particulates may reduce light penetration and lower the rate of photosynthesis and the primary productivity of an aquatic area if suspended for lengthy intervals. Aquatic vegetation such as eelgrass beds and kelp beds may also be affected. Managed fish species may suffer reduced feeding ability, leading to limited growth and lowered resistance to disease if high levels of suspended particulates persist. The contents of the suspended material may react with the dissolved oxygen in the water and result in oxygen depletion. Toxic metals and organics, pathogens, and viruses absorbed or adsorbed to fine-grained particulates in the material may become biologically available to organisms either in the water column or through food chain processes.

The discharge of dredged or fill material can change the chemistry and the physical characteristics of the receiving water at the disposal site by introducing chemical constituents in suspended or dissolved form. Reduced clarity and excessive contaminants can reduce, change or eliminate the suitability of water bodies for populations of groundfish, other fish species and their prey. The introduction of nutrients or organic material to the water column as a result of the discharge can lead to a high biochemical oxygen demand (BOD), which in turn can lead to reduced dissolved oxygen, thereby potentially affecting the survival of many aquatic organisms. Increases in nutrients can favor one group of organisms such as polychaetes or algae to the detriment of other types.

4.2.2 Fill Material

Potential Adverse Impacts

Adverse impacts to EFH from the introduction of fill material included 1) loss of habitat function and 2) changes in hydrologic patterns.

Aquatic habitats sustain remarkably high levels of productivity and support various life stages of fish species and their prey. Many times these habitats are used for multiple purposes including habitat necessary for spawning, breeding, feeding, or growth to maturity. The introduction of fill material eliminates those functions and permanently removes the habitat from production.

The discharge of dredged or fill material can modify current patterns and water circulation by obstructing flow, changing the direction or velocity of water flow and circulation, or otherwise changing the dimensions of a water body. As a result, adverse changes can occur in the location, structure, and dynamics of aquatic communities; shoreline and substrate erosion and deposition rates; the deposition of suspended particulates; the rate and extent of mixing of dissolved and suspended components of the water body; and water stratification (NMFS 1998).

Recommended Conservation Measures

1. Study all options for disposal of dredged materials, including disposal sites and methods used. Upland dredge disposal sites should be considered as an alternative to offshore disposal sites.
2. The cumulative impacts of past and current fill operations on EFH should be addressed by federal, state, and local resource management and permitting agencies and considered in the permitting process.

3. Disposal of dredge material in EFH should meet or exceed applicable state and/or federal quality standards for such disposal.
4. State and federal agencies should identify the direct and indirect impacts open-water disposal permits for dredged material may have on EFH during proposed project reviews. Benthic productivity should be determined by sampling prior to any discharge of fill material. Sampling design should be developed with input from state and federal natural resource agencies.
5. The areal extent of any disposal site in EFH should be avoided or minimized. However, in some cases, thin layer disposal may be less deleterious. All non-avoidable adverse impacts should be mitigated.
6. All spoil disposal permits should reference latitude-longitude coordinates of the site so information can be incorporated into GIS systems. Inclusion of aerial photos or benthic photos may also be required to identify precise locations and determine long-term effects.
7. Fills in estuaries and bays for development of commercial enterprises should be avoided.
8. Identify and characterize EFH habitat functions/services in the project areas.
9. Adequate compensatory mitigation should be provided for unavoidable impacts.

4.3 Vessel Operations/Transportation/Navigation

The demand by port districts to increase infrastructure capacity to accommodate additional vessel operations for cargo handling activities and marine transportation is predicted to continue. Population growth and demands for international business trade along the Pacific Rim exert pressure to expand coastal towns and port facilities, resulting in net estuary losses (Kagan 1991, Fawcett and Marcus 1991). Port expansion has become an almost continuous process due to economic growth, competition between ports, and significant increases in vessel size (NPFMC 1999). In addition, with increased population growth comes the steady demand for providing new and expanded water transit services. Finally, providing additional recreational opportunities by constructing and enlarging recreational marinas is also foreseen.

Potential Adverse Impacts

The expansion of port facilities, vessel/ferry operations, and recreational marinas can bring additional impacts to EFH. Additional land needed to improve shipping efficiency can only be accommodated by changing land-use operations or adding new land by filling aquatic habitats. New wharves and piers decrease photic penetration in the water and decreases primary production (see Section 4.6). More hard surface increases nonpoint surface discharges (see Section 2.2), adds debris sources, and reduces buffers between land use and the aquatic ecosystem. These will include direct, indirect, and cumulative impacts on shallow subtidal, deep subtidal, eelgrass beds, mudflats, sand shoals, rock reefs, and salt marsh habitats. Such impacts would be site-specific. Some activities impacting these habitats, including new channel deepening and maintenance dredging (see Section 4.1), disposal of dredged material (see Section 4.2), reduced water quality from resuspension of contaminated sediments, ballast water discharge (see Section 4.4), and shading from overwater structures (see Section 4.6), have been addressed in other sections. Additional impacts include vessel groundings, modification of water circulation (breakwaters, channels, and fill), vessel wake generation, pier lighting, anchor scour and prop scour, and the discharge of contaminants and debris.

Potential adverse impacts to EFH can occur during both the construction and operation phases. Direct impacts include permanent or temporary loss of productive forage habitat resulting from new channel deepening and maintenance dredging (see Section 4.1), turbidity-related impacts due to both dredging and disposal of dredged material (see Section 4.2), and reduced water quality from resuspension of contaminated sediments (see Section 4.1). In addition, dredging in tidal wetland areas could result in the spread of nonnative invasive plant species (see Section 4.4).

An increase in the number and size of vessels can generate more wave and surge effects on shorelines. These vessel-wake, wash events can affect shorelines depending on the wake wave energy, the water depth, and the type of shoreline. Vessel wakes can cause a significant increase in shoreline erosion, impact wetland habitat, and increase water turbidity. Vessel prop wash can also damage aquatic vegetation and disturb sediments which may increase turbidity and suspend contaminants (Klein 1997, Warrington 1999). Changes in prey communities under ferry terminals have been attributed, in part, to prop wash from ferries (Blanton et al. 2001, Haas et al. 2002).

Impacts can also occur from anchor scour. Mooring buoys, when anchored in shallow nearshore waters, can drag the anchor chain across the bottom, destroying submerged vegetation and creating a circular scour hole (Walker et al. 1989, cited in Shafer 2002). A study by Hastings et al. (1995) (cited in Shafer 2002) in Australia found that up to 18 percent of total seagrass cover was lost to mooring buoy scour.

Vessel discharges, engine operations, bottom paint sloughing, boat washdowns, painting and other vessel maintenance activities can deliver debris, nutrients and contaminants to waterways and may degrade water quality and contaminate sediments.

Inadequate flushing of marinas also results in water quality problems (U.S. Army Corps of Engineers 1993, Klein 1997). Poor flushing in marinas in Puget Sound resulted in increases in temperature, increased phytoplankton populations with nocturnal dissolved oxygen level declines resulting in organism hypoxia, and pollutant inputs (Cardwell et al. 1980). An exchange of at least 30 percent of the water in the marina during a tidal change should minimize temperature increases and dissolved oxygen problems (Cardwell et al. 1980).

Recommended Conservation Measures

1. Locate marinas in areas of low biological abundance and diversity, for example, avoiding dense beds of eelgrass or other submerged aquatic vegetation including macroalgae.
2. Excavate uplands to create marina basins rather than converting intertidal or shallow subtidal to deeper subtidal for basin creation.
3. Avoid the disturbance of beds, mudflats and wetlands as part of the project design. In situations where such impacts are unavoidable, appropriate compensatory mitigation should be incorporated into the project with the approval of appropriate regulatory agencies. Specific habitat types such as eelgrass beds need to be mitigated in-kind. For other habitat types where in-kind mitigation is unavailable, the habitat values or functions of these threatened habitats should be calculated and appropriate mitigation be provided to ensure no net loss of habitat functions. This also includes the habitat value of traditional shoreline protection materials (e.g., revetments and breakwaters). Other dredging-related conservation measures are provided in Section 4.1.
4. Leave marine riparian buffers in place to enhance intertidal microclimate and nutrient input.
5. Adequate monitoring on the success of mitigation efforts should be included as part of the project and incorporated into a mitigation and monitoring plan.
6. Conduct preconstruction surveys by qualified biologists/botanists to identify and map areas of invasive plant species existing within potential project construction areas. Eradication of non-native species should be conducted well in advance of construction.
7. Include low-wake vessel technology, appropriate routes, and best management practices for wave attenuation structures as part of the design and permit process. Vessels should be operated at sufficiently low speeds to reduce wake energy, and no-wake zones should be designated near sensitive habitats.
8. Incorporate best management practices to prevent or minimize contamination from ship bilge waters, antifouling paints, shipboard accidents, shipyard work, maintenance dredging and disposal, and nonpoint source contaminants from upland facilities related to vessel operations and navigation.
9. Locate mooring buoys in water deep to avoid grounding and minimize affects of prop wash. Use subsurface floats or other methods to prevent contact of the anchor line with the substrate.
10. Collect and treat runoff from parking lots and other impervious surfaces to remove contaminants prior to delivery to any receiving waters
11. Locate facilities in areas with sufficient water velocities to dissipate fuels and pollutants from vessels and maintain temperature and dissolved oxygen levels within acceptable ranges.
12. Locate marinas where they do not interfere with drift sectors determining the structure and function of adjacent habitats.

4.4 Introduction of Exotic Species

The introductions of exotic species into estuarine and marine habitats has been well documented (Rosecchi et al. 1993, Kohler and Courtenay 1986, Spence et al. 1996) and can be intentional (e.g., for the purpose of stock or pest control) or unintentional (e.g., fouling organisms). Exotic fish, shellfish, pathogens, and plants can enter the environment from industrial shipping (e.g., as ballast), recreational boating, aquaculture (see Section 4.11), biotechnology, and aquariums. The transportation of nonindigenous organisms to new environments can have many severe impacts on habitat (Omori et al. 1994).

Potential Adverse Impacts

Long-term impacts of the introduction of nonindigenous and reared species can change the natural community structure and dynamics, lower the overall fitness and genetic diversity of natural stocks, and pass and/or introduce exotic lethal disease. Overall, exotic species introductions create five types of negative impacts: 1) habitat alteration, 2) trophic alteration, 3) gene pool alteration, 4) spatial alteration, and 5) introduction of diseases. Habitat alteration includes the excessive colonization of exotic species (e.g., *Spartina* grasses) which preclude the growth of endemic organisms (e.g., eelgrass). The introduction of exotic species may alter community structure by predation on native species or by population explosions of the introduced species. Spatial alteration occurs when territorial introduced species compete with and displace native species. Although hybridization is rare, it may occur between native and introduced species and can result in gene pool deterioration.

Non-native plants and algae can degrade coastal and marine habitats by changing natural habitat qualities. Introduced organisms increase competition with indigenous species or forage on indigenous species, which can reduce fish and shellfish populations. Long-term impacts from the introduction of nonindigenous and reared species can change the natural community structure and dynamics, lower the overall fitness and genetic diversity of natural stocks, and pass and/or introduce exotic lethal diseases. The introduction of exotic organisms also threatens native biodiversity and could lead to changes in relative abundances of species and individuals that are of ecological and economic importance.

The introduction of bacteria, viruses, and parasites is another severe threat to EFH as it may reduce habitat quality. New pathogens or higher concentrations of disease can be spread throughout the environment resulting in deleterious habitat conditions.

Recommended Conservation Measures

1. Encourage vessels to perform a ballast water exchange in marine waters (in accordance with the U.S. Coast Guard's voluntary regulations) to minimize the possibility of introducing exotic estuarine species into similar habitats. Ballast water taken on in marine waters will contain fewer organisms and these will be less likely to become invasive in estuarine conditions than species transported from other estuaries.
2. Discourage vessels that have not performed a ballast water exchange from discharging their ballast water into estuarine receiving waters.
3. Require vessels brought from other areas over land via trailer to clean any surfaces that may harbor non-native plant or animal species (propellers, hulls, anchors, fenders, etc.). Bilges should be emptied and cleaned thoroughly using hot water or a mild bleach solution. These activities should be performed in an upland area to prevent introduction of non-native species during the cleaning process.
4. Exclude exotic species from aquaculture operations until a thorough scientific evaluation and risk assessment is performed (see Section 4.11).
5. Aquaculture facilities rearing non-native species should be located upland and use closed-water circulation systems whenever possible.
6. Treat effluent from public aquaria displays, and laboratories, and educational institutes using exotic species prior to discharge to prevent the introduction of viable animals, plants, reproductive material, pathogens, or parasites into the environment.

4.5 Pile Installation and Removal

Pilings are an integral component of many overwater and in-water structures. They provide support for the decking of piers and docks, function as fenders and dolphins to protect structures, support navigation markers, and are used to construct breakwaters and bulkheads. Materials used in pilings include steel, concrete, wood (both treated and untreated), plastic or a combination thereof. Piles are usually driven into the substrate using one of two types of hammer: impact hammers and vibratory hammers. Impact hammers consist of a heavy weight that is repeatedly dropped onto the top of the pile, driving it into the substrate. Vibratory hammers utilize a combination of a stationary, heavy weight and vibration, in the plane perpendicular to the long axis of the pile, to force the pile into the substrate. The type of hammer used depends on a variety of factors, including pile material and substrate type. Impact hammers can be used to drive all types of piles, while vibratory hammers are generally most efficient at driving piles with a cutting edge (e.g., hollow steel pipe) and are less efficient at driving "displacement" piles (those without a cutting edge that must displace the substrate). Displacement piles include solid concrete, wood, and closed-end steel pipe. While impact hammers are able to drive piles into most substrates (including hardpan, glacial till, etc.), vibratory hammers are limited to softer, unconsolidated substrates (e.g., sand, mud, gravel). Since vibratory hammers do not use force to drive the piles, the bearing capacity is not known and the piles must often be "proofed" with an impact hammer. This involves striking the pile a number of times with the impact hammer to ensure that it meets the designed bearing capacity. Under certain circumstances, piles may be driven using a combination of vibratory and impact hammers. The vibratory hammer makes positioning and plumbing of the pile easier; therefore, it is often used to drive the pile through the soft, overlying material. Once the pile stops penetrating the sediment, the impact hammer is used to finish driving the pile to final depth. An additional advantage of this method is that the vibratory hammer can be used to extract and reposition the pile, while the impact hammer cannot.

Overwater structures must often meet seismic stability criteria, requiring that the supporting piles are attached to, or driven into, the underlying hard material. This requirement often means that at least some impact driving is necessary. Piles that do not need to be seismically stable, including temporary piles, fender piles, and some dolphin piles, may be driven with a vibratory hammer, providing the type of pile and sediments are appropriate.

Piles can be removed using a variety of methods, including vibratory hammer, direct pull, clam shell grab, or cutting/breaking the pile below the mudline. Vibratory hammers can be used to remove all types of pile, including wood, concrete, and steel. However, old, brittle piles may break under the vibrations and necessitate another method. The direct pull method involves placing a choker around the pile and pulling upward with a crane or other equipment. Broken stubs are often removed with a clam shell and crane. In this method, the clam shell grips the pile near the mudline and pulls it out. In other instances, piles may be cut or broken below the mudline, leaving the buried section in place.

4.5.1 Pile Driving

Potential Adverse Impacts

Pile driving can generate intense underwater sound pressure waves that may adversely affect the ecological functioning of EFH. These pressure waves have been shown to injure and kill fish (e.g., CalTrans 2001, Longmuir and Lively 2001, Stotz and Colby 2001, Stadler, pers. obs. 2002). Injuries associated directly with pile driving are poorly studied, but include rupture of the swimbladder and internal hemorrhaging (CalTrans 2001; Abbott and Bing-Sawyer 2002; Stadler, pers. obs. 2002). Sound pressure levels (SPL) 100 decibels (dB) above the threshold for hearing is thought to be sufficient to damage the auditory system in many fishes (Hastings 2002).

The type and intensity of the sounds produced during pile driving depend on a variety of factors, including, but not limited to, the type and size of the pile, the firmness of the substrate into which the pile is being driven, the depth of water, and the type and size of the pile-driving hammer. SPLs are positively correlated with the size of the pile, as more energy is required to drive larger piles. Wood and concrete piles appear to produce lower sound pressures than hollow steel piles of a similar size, although it is not yet clear if the sounds produced by wood or concrete piles are harmful to fishes. Hollow steel piles as small as 14-inch diameter have been shown to produce SPLs that can injure fish (Reyff 2003). Firmer substrates require more energy to drive piles, and produce more intense sound pressures. Sound attenuates more rapidly with distance from the source in shallow than in deep water (Rogers and Cox 1988).

Driving hollow steel piles with impact hammers produce intense, sharp spikes of sound which can easily reach levels that injure fish. Vibratory hammers, on the other hand, produce sounds of lower intensity, with a rapid repetition rate. A key difference between the sounds produced by impact hammers and those produced by vibratory hammers is the responses they evoke in fish. When exposed to sounds which are similar to those of a vibratory hammer, fish consistently displayed an avoidance response (Enger et al. 1993, Dolat 1997, Knudsen et al. 1997, Sand et al. 2000), and did not habituate to the sound, even after repeated exposure (Dolat 1997, Knudsen et al. 1997). Fishes may respond to the first few strikes of an impact hammer with a "startle" response. After these initial strikes, the startle response wanes and the fishes may remain within the field of a potentially harmful sound (Dolat 1997, NOAA Fisheries 2001). The differential responses to these sounds are due to the differences in the duration and frequency of the sounds. When compared to impact hammers, the sounds produced by vibratory hammers are of longer duration (minutes vs. msec) and have more energy in the lower frequencies (15-26 Hz vs 100-800 Hz) (Würsig, et al. 2000, Carlson et al. 2001). Studies have shown that fish respond to particle acceleration of 0.01 m/s^2 at infrasound frequencies, that the response to infrasound is limited to the nearfield (< 1 wavelength), and the fish must be exposed to the sound for several seconds (Enger et al. 1993, Knudsen et al. 1994, Sand et al. 2000). Impact hammers, however, produce such short spikes of sound with little energy in the infrasound range, that fish fail to respond to the particle motion (Carlson et al. 2001). Thus, impact hammers may be more harmful than vibratory hammers because they produce more intense pressure waves and because the sounds produced do not elicit an avoidance response in fishes, which exposes them for longer periods to those harmful pressures.

The degree to which an individual fish exposed to sound will be affected is dependent upon a number of variables, including 1) species of fish, 2) fish size, 3) presence of a swimbladder, 4) physical condition of the fish, 5) peak sound pressure and frequency, 6) shape of the sound wave (rise time), 7) depth of the water around the pile, 8) depth of the fish in the water column, 9) amount of air in the water, 10) size and number of waves on the water surface, 11) bottom substrate composition and texture, 12) effectiveness of bubble curtain sound/pressure attenuation technology, 13) tidal currents, and 14) presence of predators.

Depending on these factors, effects on fish can range from changes in behavior to immediate mortality. There is little data on the SPL required to injure fish. Short-term exposure to peak SPL above 190 dB (re:1 µPa) are thought to injure physical harm on fish (Hastings 2002). However, 155 dB (re: 1 µPa) may be sufficient to temporarily stun small fish (J. Miner, pers. comm. 2002). Stunned fish, while perhaps not physically injured, are more susceptible to predation. Small fish are more prone to injury by intense sound than are larger fish of the same species (Yelverton et al. 1975). For example, a number of surfperches (*Cymatogaster aggregata* and *Embiotoca lateralis*) were killed during impact pile driving (Stadler, pers. obs. 2002). Most of the dead fish were the smaller *C. aggregata* and similar sized specimens of *E. lateralis*, even though many larger *E. lateralis* were in the same area. Dissections revealed that the swimbladder of the smallest fish (80 mm forklength [FL]) were completely destroyed, while those of the largest individual (170 mm FL) was nearly intact, indicating a size-dependent effect. The SPLs that killed these fish are not yet known. Of the reported fish kills associated with pile driving, all have occurred during use of an impact hammer on hollow steel piles (Longmuir and Lively 2001, NOAA Fisheries 2001, Stotz and Colby 2001, NOAA Fisheries 2003).

Systems successfully designed to reduce the adverse effects of underwater SPLs on fish have included the use of air bubbles. Both confined (i.e., metal or fabric sleeve) and unconfined air bubble systems have been shown to attenuate underwater sound pressures up to 28 dB (Wursig et al. 2000, Longmuir and Lively 2001, Christopherson and Wilson 2002, Reyff and Donovan 2003). When using an unconfined air bubble system in areas of strong currents, it is critical that the pile is fully contained within the bubble curtain. To accomplish this, adequate air flow and ring spacing both vertically and distance from the pile are factors that should be considered when designing the system.

Recommended Conservation Measures

1. Install hollow steel piles with an impact hammer at a time of year when larval and juvenile stages of fish species with designated EFH are not present. If this is not possible, then the following measures should be incorporated to minimize adverse effects.
2. Drive piles during low tide periods when located in intertidal and shallow subtidal areas.
3. Use a vibratory hammer when driving hollow steel piles. Under those conditions where impact hammers are required for reasons of seismic stability or substrate type, it is recommended that the pile be driven as deep as possible with a vibratory hammer prior to the use of the impact hammer.
4. Monitor peak SPLs during pile driving to ensure that they do not exceed the 190 dB re:1 µPa threshold for injury to fish.
5. Implement measures to attenuate the sound should SPLs exceed the 180 dB re: 1 µPa threshold. If sound pressure levels exceed acceptable limits, implement mitigative measures. Methods to reduce the sound pressure levels include, but are not limited to, the following:
   a) Surround the pile with an air bubble curtain system or air-filled coffer dam.
   b) Since the sound produced has a direct relationship to the force used to drive the pile, use of a smaller hammer should be used to reduce the sound pressures.
   c) Use a hydraulic hammer if impact driving cannot be avoided. The force of the hammer blow can be controlled with hydraulic hammers; reducing the impact force will reduce the intensity of the resulting sound.
6. Drive piles when the current is reduced (i.e., centered around slack current) in areas of strong current to minimize the number of fish exposed to adverse levels of underwater sound.

4.5.2 Pile Removal

Potential Adverse Impacts

The primary adverse effect of removing piles is the suspension of sediments, which may result in harmful levels of turbidity and release of contaminants contained in those sediments (see Section 4.1). Vibratory pile removal tends to cause the sediments to slough off at the mudline, resulting in relatively low levels of suspended sediments and contaminants. Vibratory removal of piles is gaining popularity because it can be used on all types of piles, providing that they are structurally sound. Breaking or cutting the pile below the mudline may suspend only small amounts of sediment, providing the stub is left in place and little digging is required to access the pile. Direct pull or use of a clamshell to remove broken piles, however, may suspend large amounts of sediment and contaminants. When the piling is pulled from the substrate using these two methods, sediments clinging to the piling will slough off as it is raised through the water column, producing a potentially harmful plume of turbidity and/or contaminants. The use of a clamshell may suspend additional sediment if it penetrates the substrate while grabbing the piling.

While there is a potential to adversely affect EFH during the removal of piles, many of those removed are old creosote-treated timber piles. In some cases, the long-term benefits to EFH obtained by removing a consistent source of contamination may outweigh the temporary adverse effects of turbidity.

Recommended Conservation Recommendations

1. Remove piles completely rather than cutting or breaking off if the pile is structurally sound.
2. Minimize the suspension of sediments and disturbance of the substrate when removing piles. Measures to help accomplish this include, but are not limited to, the following:
   a) When practicable, remove piles with a vibratory hammer, rather than the direct pull or clamshell method.
   b) Remove the pile slowly to allow sediment to slough off at, or near, the mudline.
   c) The operator should first hit or vibrate the pile to break the bond between the sediment and pile to minimize the potential for the pile to break, as well as reduce the amount of sediment sloughing off the pile during removal.
   d) Place a ring of clean sand around the base of the pile. This ring will contain some of the sediment

that would normally be suspended.
    e) Encircle the pile, or piles, with a silt curtain that extends from the surface of the water to the substrate.
3. Complete each pass of the clamshell to minimize suspension of sediment if pile stubs are removed with a clamshell.
4. Fill all holes left by the piles with clean, native sediments if possible.
5. Place piles on a barge equipped with a basin to contain all attached sediment and runoff water after removal. Creosote-treated timber piles should be cut into short lengths to prevent reuse, and all debris, including attached, contaminated sediments, should be disposed of in an approved upland facility.
6. Drive broken/cut stubs using a pile driver, sufficiently below the mudline to prevent release of contaminants into the water column as an alternative to their removal.

4.6 Overwater Structures

Overwater structures include commercial and residential piers and docks, floating breakwaters, barges, rafts, booms, and mooring buoys. These structures are typically located in intertidal areas out to about 15 meters below the area exposed by the mean lower low tide (i.e., the shallow subtidal zone). Light, wave energy, substrate type, depth and water quality are the primary factors controlling the plant and animal assemblages found at a particular site. Overwater structures and associated activities can alter these factors and interfere with key ecological functions such as spawning, rearing, and refugia. Site-specific factors (e.g., water clarity, current, depth, etc.) and the type and use of a given overwater structure determine the occurrence and magnitude of these impacts.

<u>Potential Adverse Impacts</u>

Overwater structures and associated developments may adversely affect EFH in a variety of ways, primarily by changes in ambient light conditions, alteration of the wave and current energy regime, and through activities associated with the use and operation of the facilities (Nightingale and Simenstad 2001b).

Overwater structures create shade which reduces the light levels below the structure. The size, shape and intensity of the shadow cast by a particular structure depends upon its height, width, construction materials, and orientation. High and narrow piers and docks produce narrower, more diffuse shadows than do low and wide structures. Increasing the numbers of pilings used to support a given pier increases the shade cast by pilings on the under-pier environment. In addition, less light is reflected underneath structures built with light-absorbing materials (e.g., wood) than from structures built with light-reflecting materials (e.g., concrete or steel). Structures that are oriented north-south produce a shadow that moves across the bottom throughout the day, resulting in a smaller area of permanent shade than those that are oriented east-west.

The shadow cast by an overwater structure affects both the plant and animal communities below the structure. Distributions of plants, invertebrates, and fishes have been found to be severely limited in under-dock environments when compared to adjacent, unshaded vegetated habitats. Light is the single most important factor affecting aquatic plants. Under-pier light levels have been found to fall below threshold amounts for the photosynthesis of diatoms, benthic algae, eelgrass, and associated epiphytes and other autotrophs. These photosynthesizers are an essential part of nearshore habitat and the estuarine and nearshore foodwebs that support many species of marine and estuarine fishes. Eelgrass and other macrophytes can be reduced or eliminated, even through partial shading of the substrate, and have little chance to recover.

Fishes rely on visual cues for spatial orientation, prey capture, schooling, predator avoidance, and migration. The reduced-light conditions found under an overwater structure limit the ability of fishes, especially juveniles and larvae, to perform these essential activities. Shading from overwater structures may also reduce prey organism abundance and the complexity of the habitat by reducing aquatic vegetation and phytoplankton abundance (Kahler et al. 2000, Haas et al. 2002). Glasby (1999) found that epibiotic assemblages on pier pilings at marinas subject to shading were markedly different than in surrounding areas. Other studies have shown shaded epibenthos to be reduced relative to that in open areas. These factors are thought to be responsible for the observed reductions in juvenile fish populations found under piers and the reduced growth and survival of fishes held in cages under piers, when compared to open habitats (Able et al. 1998, Duffy-Anderson and Able 1999).

The shadow cast by an overwater structure may increase predation on EFH managed species by creating a light/dark interface that allows ambush predators to remain in a darkened area (barely visible to prey) and watch for prey to swim by against a bright background (high visibility) (Helfman 1981). Prey species moving around the structure are unable to see predators in the dark area under the structure and are more susceptible to predation. Furthermore, the reduced vegetation (i.e., eelgrass) densities associated with overwater structures decrease the available refugia from predators.

In addition to piscivorous predation, in-water structures (e.g., pilings) also provide perching platforms for avian predators such as double-crested cormorants (*Phalacrocorax auritis*), from which they can launch feeding forays or dry their plumage.

Wave energy and water transport alterations from overwater structures can impact the nearshore detrital foodweb by altering the size, distribution, and abundance of substrate and detrital materials. Disruption of longshore transport can alter substrate composition and can present potential barriers to the natural processes that build spits and beaches and provide substrates required for plant propagation, fish and shellfish settlement and rearing, and forage fish spawning.

Pilings can alter adjacent substrates with increased shell deposition from piling communities and changes to substrate bathymetry (see Section 4.5). Changes in substrate type can alter the nature of the flora and fauna native to a given site. In the case of pilings, native dominant communities typically associated with sand, gravel, mud, and eelgrass substrates are replaced by communities associated with shell hash substrates.

Treated wood used for pilings and docks releases contaminants into saltwater environs. Poly-aromatic hydrocarbons (PAHs) are commonly released from creosote-treated wood. PAHs can cause a variety of deleterious effects (cancer, reproductive anomalies, immune dysfunction, and growth and development impairment) to exposed fish (Johnson et al. 1999, Johnson 2000, Stehr et al. 2000). Wood also is commonly treated with other chemicals such as ammoniacal copper zinc arsenate (ACZA) and chromated copper arsenate (CCA) (Poston 2001). These preservatives are known to leach into marine waters for a relatively short period of time after installation, but the rate of leaching is highly variable and dependent on many factors. Concrete or steel, on the other hand, are relatively inert and do not leach contaminants into the water.

Construction and maintenance of overwater structures often involves driving of pilings (see Section 4.5) and dredging of navigation channels (see Section 4.1). Both activities may also adversely affect EFH.

While the effect of some individual overwater structures on EFH may be minimal, the overall impact may be substantial when considered cumulatively. The additive effects of these structures increases the overall magnitude of impact and reduces the ability of the EFH to support native plant and animal communities.

Recommended Conservation Measures

1. Use upland boat storage whenever possible to minimize need for overwater structures.
2. Locate overwater structures in sufficiently deep waters to avoid intertidal and shade impacts, to minimize or preclude dredging, to minimize groundings, and to avoid displacement of submerged aquatic vegetation, as determined by a pre-construction survey.
3. Design piers, docks, and floats to be multi-use facilities in order to reduce the overall number of such

structures and the nearshore habitat that is impacted.
4. Incorporate measures that increase the ambient light transmission under piers and docks. These measures include, but are not limited to, maximizing the height of the structure and minimizing the width of the structure to decrease shade footprint; grated decking material; using solar tubes to direct light under the structure and glass blocks to direct sunlight under the structure; illuminating the under-structure area with metal halide lamps and use of reflective paint or materials (e.g., concrete or steel instead of materials that absorb light such as wood) on the underside of the dock to reflect ambient light; using the fewest number of pilings necessary to support the structures to allow light into under-pier areas and minimize impacts to the substrate; and aligning piers, docks and floats in north-south orientation to allow arc of sun to cross perpendicular to structure and reduce duration of light limitation.
5. Use floating breakwaters whenever possible and remove them during periods of low dock use. Encourage seasonal use of docks and off-season haul-out.
6. Use waveboards to minimize effects on littoral drift and benthic habitats.
7. Locate floats in deep water to avoid light limitation and grounding impacts to the intertidal zone, and maintain at least one foot of water between the substrate and the bottom of the float.
8. Conduct in-water work during the time of year when EFH-managed species and prey species are least likely to be impacted.
9. Avoid use of treated wood timbers or pilings to the extent practicable. Use of alternative materials such as untreated wood, concrete, or steel is recommended.
10. Fit all pilings and navigational aids, such as moorings and channel markers, with devices to prevent perching by piscivorous bird species.
11. Orient night lighting such that illumination of the surrounding waters is avoided.
12. Mitigate for unavoidable impacts to benthic habitats that is adequately provided, properly monitoried, and adaptively managed.

4.7 Flood Control/Shoreline Protection

The protection of riverine and estuarine communities from flooding events can result in varying degrees of change in the physical, chemical, and biological characteristics of existing shoreline and riparian habitat. The use of dikes and berms can also have long-term adverse effects in tidal marsh and estuarine habitats. Tidal marshes are highly variable, but typically have freshwater vegetation at the landward side, saltwater vegetation at the seaward side, and a gradient of species in between that are in equilibrium with the prevailing climatic, hydrographic, geological, and biological features of the coast. These systems normally drain through highly dendritic tidal creeks that empty into the bay or estuary. Freshwater entering along the upper edges of the marsh drain across the surface and enter the tidal creeks. Structures placed for coastal shoreline protection include, but are not limited to, concrete or wood seawalls; rip-rap revetments (sloping piles of rock placed against the toe of the dune or bluff in danger of erosion from wave action); dynamic cobble revetments (natural cobble placed on an eroding beach to dissipate wave energy and prevent sand loss); vegetative plantings; and sandbags.

Potential Adverse Impacts

Dikes, levees, ditches, or other water controls at the upper end of a tidal marsh can cut off all tributaries feeding the marsh, preventing freshwater flushing and annual flushing, annual renewal of sediments and nutrients, and the formation of new marshes. Water controls within the marsh proper intercept and carry away freshwater drainage, block freshwater from flowing across seaward portions of the marsh, increase the speed of runoff of freshwater to the bay or estuary, lower the water table, permit saltwater intrusion into the marsh proper, and create migration barriers for aquatic species. In deeper channels where reducing conditions prevail, large quantities of hydrogen sulfide are produced that are toxic to marsh grasses and other aquatic life. Acid conditions of these channels can also result in release of heavy metals from the sediments

Long-term effects on the tidal marsh include land subsidence (sometimes even submergence), soil compaction, conversion to terrestrial vegetation, greatly reduced invertebrate populations, and general loss of productive wetland characteristics. Loss of these low-salinity environments reduces estuarine fertility, restricts suitable habitat for aquatic species, and creates abnormally high salinity during drought years. Low-salinity environments form a barrier that prevents the entrance of many marine species, including competitors, predators, parasites and pathogens.

Armoring of shorelines to prevent erosion and maintain or create shoreline real estate simplifies habitats, reduces the amount of intertidal habitat, and affects nearshore processes and the ecology of a myriad of species (Williams and Thom 2001). Hydraulic effects to the shoreline include increased energy seaward of the armoring, reflected wave energy, dry beach narrowing, substrate coarsening, beach steepening, changes in sediment storage capacity, loss of organic debris, and downdrift sediment starvation (Williams and Thom 2001). Installation of breakwaters and jetties can result in community changes from burial or removal of resident biota; changes in cover and preferred prey species; and predator attraction (Williams and Thom 2001). As with armoring, breakwaters and jetties modify hydrology and nearshore sediment transport as well as movement of larval forms of many species (Williams and Thom 2001).

Recommended Conservation Measures

1. Minimize the loss of riparian habitats as much as possible.
2. The diking and draining of tidal marshlands and estuaries should not be undertaken unless a satisfactory compensatory mitigation plan is in effect and monitored.
3. Wherever possible, “soft” approaches (such as beach nourishment, vegetative plantings, and placement of large woody debris) to shoreline modifications should be utilized.
4. Include efforts to preserve and enhance EFH by providing new gravel for spawning areas; removing barriers to natural fish passage; and using weirs, grade control structures, and low flow channels to provide the proper depth and velocity for fish.
5. Construct a low-flow channel to facilitate fish passage and help maintain water temperature in reaches where water velocities require armoring of the riverbed.
6. Replace in-stream fish habitat by providing rootwads, deflector logs, boulders, rock weirs and by planting shaded riverine aquatic cover vegetation.
7. Use an adaptive management plan with ecological indicators to oversee monitoring and ensure mitigation objectives are met. Take corrective action as needed.

4.8 Water Control Structures

Many coastal areas of the Pacific Northwest utilize Water Control Structures (WCSs), such as pumping stations and tidegates, to regulate water levels in nearshore and estuary settings. WCSs enable certain agricultural crops to survive through floods, maintain high water tables, and manage the threat of saltwater intrusion. In some cases, infrastructures such as roads, industrial and residential developments, and sewer treatment plants have been built because of the enhanced drainage. These structures have been installed within streams, blind and distributary sloughs, and marsh/wetlands within estuarine and nearshore areas.

Tide gates have typically been installed on culverts passing through levees, dikes, and berms to prevent tidal inundation in areas landward of the berms. As the tide backs up and closes the tide gate, fish passage upstream is blocked. As the tide turns and begins to flow out or the river level drops, a conventional tide gate opens a little but often not enough to allow upstream passage or with such velocity as to constitute a complete or partial blockage (Charland 1998). Pump stations are used to maintain more consistent control of water levels in nearshore and estuary settings. Some pumps are also used in conjunction with tide gates; many act as dams by stopping tidal or river stage levels, thus extending the capacity of the drainage system. While there is variability in the design and operation of these structures, they generally pump surface water from the drainage system to the respective receiving body.

Potential Adverse Impacts

Adverse effects to EFH from the installation and operation of WCSs can occur through 1) partially or completely blocked habitat, 2) altered water chemistry composition through suppressed mixing of fresh and saltwater, 3) decreased sediment and nutrient delivery, and 4) degraded water quality through thermal loading.

Various life stages of some EFH-managed species utilize nearshore and estuarine habitats, and food produced from these areas in the form of small fish and other aquatic organisms are important for overall food web function (PFMC 1998, PFMC 2003). WCSs can limit or eliminate habitat access to areas that may be important for food sources and refuge from predators of these species.

Depending on their location, WCSs alter the normal circulation and mixing of fresh and saltwater. Estuaries are biologically rich and productive areas, partly because of the complex gradient of fresh and salt water mixing process. Estuaries accumulate nutrients such as potassium and nitrogen, which are concentrated and recycled in a repeating interactive process by which the incoming tidal water resuspends nutrients at the fresh-saltwater interface while moving them back up the estuary to meet the seaward moving land-based nutrients (Day 1989). Estuarine food chains are extremely complex and sensitive to alterations in the physical and chemical range of stresses (Day 1989). Loss or disruption of one element can have a cascading effect on species presence and productivity. The inhibition of the gradual mixing of salt and fresh water and nutrients over the original volume of habitat can decrease the overall productivity of the estuary and may cause prey community changes.

Often WCSs impound water for various amounts of time, which can lead to premature sediment and nutrient deposition and cause a subsequent need to dredge behind the structure. Sediment deposition within estuarine and nearshore areas is important for beach nourishment, and sediments often serve as absorptive surfaces for nutrients.

Impounded water can result in increased thermal loading which, in turn, can interfere with physiological processes, behavioral changes, and disease enhancement (Bell 1986). Increased thermal loading can also cause increased microbial activity and vegetative growth, which in turn can deplete levels of dissolved oxygen (Waldichuk 1993, Spence et al. 1996). These impacts may combine to affect entire aquatic systems by changing primary and secondary productivity, community respiration, species composition, biomass, and nutrient dynamics (Hall et al. 1978). These effects, while perhaps more acute in the regulated watercourse, can nonetheless be manifested in the receiving body as well, particularly in areas where much of the historic estuary habitat is regulated by WCSs.

<u>Recommended Conservation Measures</u>

1. Avoid installing new WCSs. In some cases, tidegates that replace dams or pump stations (those which completely block habitat) can improve habitat conditions by enhancing fish passage and water circulation.
2. Design WCSs to enhance habitat access and water circulation.
3. Assess habitat potential or value behind the WCS by investigating current and potential aquatic vegetation, the volume and depth of the water body, the amount and timing of freshwater inflow, the presence of upland rearing and spawning habitat, and the relative salinity of the water body.
4. Assess the hydrology of the regulated land’s tolerance for increased water exchange. The assessment should account for active management of the WCS to allow increased water exchange during critical periods. Existing programs that compensate landowners for lost production of land can be investigated (such as the Conservation Reserve Enhancement Program administered by the United States Department of Agriculture) if appropriate.
5. Design WCSs to mimic natural water exchange velocities. This can be done by maximizing the conveyance of water through increased width, thus reducing flow velocities during periods the gates are open.
6. Utilize WCS materials that are nontoxic and noncorrosive. Treated wood should not be used.
7. Stabilize associated banks through bio-engineered means, minimizing the use of riprap and incorporating native materials as appropriate.
8. Install WCS during low flow periods and tidal stage; incorporate appropriate erosion and sediment control BMPs, and have an equipment spill and containment plan and appropriate materials onsite.
9. Monitor WCS operations to assess impacts on water temperatures, dissolved oxygen, and other

applicable parameters. Adaptive management should be designed to minimize impacts.

4.9 Log Transfer Facilities/In-water Log Storage

Using rivers, estuaries, and bays to transport logs was the primary means of transportation and storage historically in the Pacific Northwest. Log storage within the bays and estuaries remains an issue in several Pacific Northwest bays. Using estuaries and bays and nearby uplands for storage of logs is common in Alaska, with most of Alaska's LTFs existing in Southeast Alaska and a few in Prince William Sound.

Potential Adverse Impacts

Log handling and storage in the estuary and intertidal zones of rivers can result in water quality degradation and modifications to habitat. An LTF is a facility which is constructed in whole or part in waters of the United States and which is utilized for the purpose transferring commercially harvested logs to or from a vessel or log raft, including the formation of a log raft. (EPA 2000). LTFs may include a crane, an A-frame structure, conveyor, slide or ramp, and are used move logs into the water. Logs can also be placed in the water at the site by helicopters and barges. The physical adverse impacts from these structures are similar in many ways to those of floating docks and other "over-water" structures (see Section 4.6).

EFH may also be physically impacted from activities associated with LTFs. Bark and wood debris may impact EFH as a result of the abrasion of log surfaces from transfer equipment. After the logs have entered the water, they are usually bundled into rafts and hooked to a tug for shipment. In the process, bark and other wood debris can pile up on the ocean floor. The piles can "smother" clams, mussels, some seaweed, kelp and grasses, with the bark sometimes remaining for decades. Accumulation of bark debris in shallow and deep water environments has resulted in locally decreased epifaunal macrobenthos richness and abundance (Kirkpatrick et al. 1998, Jackson 1986), which can ultimately impact various life-stages of groundfish.

Storage of logs may also result in significant release soluble, organic compounds. Log bark may affect groundfish by significantly increasing oxygen demand within the area of accumulation (PNPCC 1971). High oxygen demand can lead to an anaerobic zone where toxic sulfide compounds are generated, particularly in brackish and marine waters. Leaching of soluble organic compounds also leads to cumulative oxygen demand and reduced visibility. Reduced oxygen levels, anaerobic conditions, and the presence of toxic sulfide compounds are presumed to lead to reduced production of groundfish species and their forage base. Anaerobic areas reduce available habitat. In addition, soils at onshore facilities where logs are decked are often contaminated with gasoline, diesel fuel, solvents, etc., from trucks and heavy equipment. These contaminants can leach into nearshore EFH.

The physical, chemical, and biological impacts of LTF operations can be substantially reduced by adherence to appropriate siting and operational constraints. In 1985, the Alaska Timber Task Force (ATTF) developed guidelines to "delineate the physical requirements necessary to construct a log transfer and associated facilities, and in context with requirements of applicable law and regulations, methods to avoid or control potential impacts from these facilities on water quality, aquatic and other resources." Since 1985, the ATTF Guidelines have been applied to new LTFs through the requirements of National Pollutant Discharge Elimination System (NPDES) permits and other state and federal programs (EPA 1996). Adherence to guidelines such as the ATTF operational and siting guidelines and BMPs in the NPDES General Permit will reduce the 1) amount of bark and wood debris which enters the marine and coastal environment, 2) the potential for displacement or harm to aquatic species, and 3) accumulation of bark and wood debris on the ocean floor. The following conservation measures reflect those guidelines.

Recommended Conservation Measures

1. Storage and handling of logs should be restricted or eliminated from waters where state and federal

water quality standards cannot be met at all times.
2. Minimize potential impacts of log storage by employing effective bark and wood debris controls, collection, and disposal methods at log dumps, raft building areas, and mill-side handling zones; avoiding the free-fall dumping of logs; using easy let-down devices for placing logs in the water; and bundling logs prior to water storage (bundles should not be broken except on land and at millside).
3. Storage of logs should not take place where they will ground at any time or shade aquatic vegetation.
4. Avoid siting log storage areas and LTFs in sensitive habitat and areas important for specified species.
5. Site log storage areas and LTFs in areas with good currents and tidal exchanges.
6. Recommend land-based storage sites with the goal of eliminating in-water storage of logs.
7. For the Alaska region, also see the following link: Log Transfer Facility (LTF) Guidelines: http://www.fs.fed.us/r10/TLMP/F_PLAN/APPEND_G.PDF.

4.10 Utility Line/Cables/Pipeline Installation

With the continued development of coastal regions comes greater demand for the installation of cables, utility lines for power and other services, and pipelines for water, sewage, etc. The installation of pipelines, utility lines, and cables can have direct and indirect impacts on the offshore, nearshore, estuarine, wetland, beach, and rocky shore coastal zone habitats. The coastal zone can be as narrow as a few feet in some areas to hundreds of miles inland in others, and it is not just development in the nearshore coastal regions that can cause impacts. Many of the primary and direct impacts occur during the construction phase of installation, such as with the ground disturbance in the clearing of the right-of-way, access roads, and equipment staging areas. Indirect impacts can include increased turbidity, saltwater intrusion, accelerated erosion, and the introduction of urban and industrial pollutants.

Potential Adverse Impacts

Adverse effects to EFH from the installation of pipelines, utility lines, and cables can occur through 1) destruction of organisms and habitat, 2) turbidity impacts, 3) resuspension of contaminants, and 4) changes in hydrology.

Destruction of organisms and habitats can occur in the right-of-way of pipeline or cable. This destruction can lead to long-term or permanent damage depending on the degree and type of habitat disturbance and the mitigation measures employed. Shallow water environments, rocky reefs, nearshore and offshore rises, salt, and freshwater marshes (wetlands), and estuaries are more likely to be adversely impacted than open-water habitats. This is due to their higher sustained biomass and lower water volumes, which decrease their ability to dilute and disperse suspended sediments (Gowen 1978).

Because vegetated coastal wetlands provide forage and protection to commercially important invertebrates and fish, marsh degradation due to plant mortality, soil erosion, or submergence will eventually decrease productivity. Vegetation loss and reduced soil elevation within pipeline construction corridors should be expected with the continued use of current double-ditching techniques (Polasek 1997).

Increased water turbidity from higher than normal sediment loading can result in decreased primary production. Depending on the time of year of the construction, adverse impacts can occur, such as during highly productive spring phytoplankton blooms or times when organisms are already under stressed conditions. Changes in turbidity can temporarily alter phytoplankton communities. Depending upon the severity of the turbidity, these changes in water clarity can affect the EFH habitat functions of species higher in the food chain.

Another impact is resuspension of contaminants such as heavy metals and pesticides from the sediment, which can have lethal effects (Gowen 1978). Spills of petroleum products, solvents, and other construction-related material can also adversely affect habitat.

Pipeline canals have the potential to change the hydrology of coastal areas by 1) facilitating rapid drainage of interior marshes during low tides or low precipitation, 2) reducing or interrupting freshwater inflow and associated littoral sediments, and 3) allowing saltwater to move father inland during periods of high tides (Chabreck 1972). Saltwater intrusion into freshwater marsh often causes loss of salt-intolerant emergent and submerged aquatic plants (Chabreck 1972, Pezeshki 1987), erosion, and net loss of soil organic matter (Craig et al. 1979).

Recommended Conservation Measures

1. Align crossings along the least environmentally damaging route. Sensitive habitats such as hard-bottom (e.g., rocky reefs), submerged aquatic vegetation, oyster reefs, emergent marsh, sand and mud flats, should be avoided. If unavoidable, compensatory mitigation should be implemented.
2. Use horizontal directional drilling where cables or pipelines would cross salt marsh, vegetated inter-tidal zones, or steep erodible bluff areas adjacent to the inter-tidal zone, to avoid surface disturbances.
3. Avoid construction of permanent access channels since they disrupt natural drainage patterns and destroy wetlands through excavation, filling, and bank erosion.
4. Store and contain excavated material on uplands. If storage in wetlands or waters cannot be avoided, alternate stockpiles should be used to allow continuation of sheet flow. Stockpiled materials should be stored on construction cloth rather than bare marsh surfaces, sea grasses, or reefs.
5. Backfill excavated wetlands with either the same or comparable material capable of supporting similar wetland vegetation. Original marsh elevations should be restored. Topsoil and organic surface material such as root mats should be stockpiled separately and returned to the surface of the restored site. Adequate material should be used so that following settling and compaction of the material, the proper preproject elevation is attained. If excavated materials are insufficient to accomplish this, similar grain size material should be used to restore the trench to the required elevation. After backfilling, erosion protection measures should be implemented where needed.
6. Use existing rights-of-way whenever possible to lessen overall encroachment and disturbance of wetlands.
7. Bury pipelines and submerged cables where possible. Unburied pipelines or pipelines buried in areas where scouring or wave activity eventually exposes them run a much greater risk of damage leading to leaks or spills.
8. Remove inactive pipelines and submerged cables unless they are located in sensitive areas (e.g., marsh, reefs, sea grass, etc.) or located in areas that present no safety hazard. If allowed to remain in place, pipelines should be properly pigged, purged, filled with seawater, and capped prior to abandonment in place.
9. Use silt curtains or other type barriers to reduce turbidity and sedimentation if sea grass or oyster reefs occur at or near the project site. These silt barriers should extend at least 100 feet beyond the limits of the sea grass beds or oyster reefs. If sea grasses and oyster reefs cannot be avoided, pre- and post-construction surveys should be completed to determine project impacts and mitigation needs.
10. Access for equipment should be limited to the immediate project area. Tracked vehicles are preferred over wheeled vehicles. Consideration should be given to the use of mats and boards to avoid sensitive areas. Equipment operators should be informed to avoid sensitive areas. Sensitive areas should be clearly marked to ensure that equipment operators do not traverse them.
11. Limit construction equipment to the minimum size necessary to complete the work. Shallow-draft equipment should be employed so as to minimize impacts and eliminate the necessity of temporary access channels. The size of the pipeline trench proper should also be minimized. The push-ditch method, in which the trench is immediately backfilled, reduces the impact duration, and should therefore be employed when possible.
12. Conduct construction during the time of year that will have the least impact on sensitive habitats and species.
13. Suspend transmission lines beneath existing bridges or directional boring under streams to reduce the environmental impact. If transmission lines span streams, site towers a minimum of 200 feet from streams.

Activities on the continental shelf

14. Shunt drill cuttings through a conduit and discharge near the sea floor, or transport ashore.
15. Locate drilling and production structures, including pipelines, at least one mile from the base of a hard-bottom habitat.
16.a) Bury pipelines to a minimum of three feet beneath the sea floor, whenever possible. Particular considerations (i.e., currents, ice scour) may require deeper burial or weighting to maintain adequate cover. Buried pipeline and cables should be examined periodically for maintenance of adequate earthen cover. b) Where burial is not possible, such as in hard-bottomed areas, pipelines and cables should be attached to substrate to avoid unnecessary conflicts with fishing gear. Wherever possible the route should be marked by lighted buoys and/or lighted ranges on platforms to reduce the risk of damage to fishing gear and the pipelines. c) Alignments should be located along routes that minimize damage to marine and estuarine habitat. Avoid laying cable over high relief bottom habitat and across "live" bottom habitats such as coral and sponge. If coral or sponge habitats are encountered, NMFS would be interested in position and description information. d) Where user conflicts are likely, consult and coordinate with fishing stakeholder groups through the appropriate Fishery Management Council during the route-planning process in order to minimize conflict.
17. Avoid all natural reefs and banks, as well as artificial reef areas. Hard-bottom areas should be avoided to permit cable or pipeline burial. If unavoidable, compensatory mitigation should be mitigated.

4.11 Commercial Utilization of Habitat

Productive embayments are often used for commercial culturing and harvesting operations. These locations provide a source of warmer water temperatures and protected waters, thereby providing excellent growout sites for oyster and mussel culturing. These operations may occur in areas of productive eelgrass beds. The commercial harvest of nearshore giant kelp is another habitat type that is used. Giant kelp forest canopies serve as nursery, feeding grounds, and/or shelter to a variety of groundfish species and their prey (Cross and Allen 1993, Feder et al. 1974, Foster and Schiel 1985). In addition, when kelp plants are naturally broken free of their holdfasts, drift kelp is produced. Kelp detritus supports high secondary production and prey for many fishes (Vetter 1995).

<u>Potential Adverse Impacts</u>

Adverse impacts to EFH by operations that directly or indirectly utilize habitat include 1) discharge of organic waste/contaminants, 2) impacts to the seafloor bed, 3) risk if introducing undesirable species, 4) impacts on estuarine food webs, and 5) impacts on kelp forest communities.

The culture of estuarine and marine species in estuarine areas can reduce or degrade habitats used by native species, depending on the location and operation of these facilities. A major concern of culture operations is the discharge of organic waste. The introduction of antibiotics and other drugs in medicated feeds is also a concern. Wastes are composed primarily of feces and excess feed. The buildup of waste products into the receiving waters will depend upon water depths and circulation patterns. The release of these wastes can introduce nutrients or organic materials into the surrounding water body and lead to a high BOD leading to lower dissolved oxygen levels, thereby potentially affecting the survival of many aquatic organisms in the area. Nutrient overloads at the discharge site can also induce changes in community composition and structure, potentially favoring one group of organisms to the detriment of other.

In the case of cage mariculture operations for grow-out operations, impacts to the seafloor below the cages or pens can occur. The build-up of organic materials on the sea floor can impact the composition and diversity of the bottom-dwelling community (e.g., prey organisms for EFH species). Growth of submerged aquatic vegetation, which can provide shelter and nursery habitat for a number of fish species and their prey, can be inhibited by shading effects. Disruption of eelgrass habitat by management activities (e.g., the dumping of shell with spawn on eelgrass beds, damage to eelgrass due to subsequent water or wind shear against the sharp oyster shells, repeated mechanical raking or trampling) associated with this category are also of concern, though few studies have documented impacts. It is known that hydraulic dredges used to harvest oysters in coastal bays with eelgrass habitat can cause long-term adverse impacts to eelgrass beds, reducing or eliminating the beds (Phillips 1984).

The rearing of non-native, ecologically undesirable species may pose a risk of escape or accidental release into areas adversely affecting the ecological balance. Escape or other release into the environment can result in competition with native, wild fish for food, mates, spawning sites, which, if followed by successful interbreeding with wild stocks, can result in genetic dilution. Escapees can also pose a risk of transmission of disease to wild stocks.

Concern has also been expressed about extensive shellfish culture in estuaries and their impacts on estuarine food webs. Oysters are efficient filter feeders and can change the trophic structure by removal of the microalgae and zooplankton that are also the food source for salmon prey species. However, the extent of this effect, if any, is unknown, especially in light of the fact that native oysters were once present in large quantities co-existing with other species. Some effects might also be offset by the structure that oyster shells create, which creates shelter for a diverse biota.

Kelp is harvested for several reasons, including directly obtaining its by-products as well as indirectly for use as a food source in abalone culturing and as a substrate in the Pacific herring fishery. Harvesting can have a variety of possible impacts on the habitat functions provided by kelp canopies. For example, giant kelp provides refuge to prey resources utilized by some EFH species. The kelp canopy also serves as habitat for canopy-dwelling invertebrates and can have an enhancing effect on fish recruitment and abundance. Removal of the canopy may affect some species by potentially displacing species such as young-of-the-year or juvenile rockfishes (Miller and Geibel 1973).

Recommended Conservation Measures

1. Site mariculture operations away from subaquatic vegetation areas. Facilities should be close-circuited and located in upland areas as often as possible. Tidally influenced wetlands should not be enclosed or impounded for mariculture purposes, including hatchery and grow-out operations. Siting of facilities should also take into account the size of the facility, proximity of wild fish stocks, migratory patterns, competing uses, hydrographic conditions, and upstream uses.
2. Determine benthic productivity by sampling prior to any operations. Areas of high productivity should be avoided to the maximum extent possible. Sampling design should be developed with input from local, state, Tribal and federal resource agencies.
3. Investigate water depths and circulation patterns where cage mariculture operations are undertaken to insure conditions are adequate to preclude the buildup of waste products, excess feed, and chemical agents.
4. Undertake a thorough scientific review and risk assessment before any non-native species are allowed to be introduced. Any net pen structure should have small enough webbing to prevent entanglement by prey species. Mitigation should be provided for the areas impacted by the facility.
5. Encourage research into the timing of fish recruitment to kelp canopies and the response of canopy dwelling juvenile groundfish to kelp harvesting operations in order to minimize potential adverse impacts to canopy habitat function.
6. Encourage development of harvesting methods to minimize impacts on plant communities such as the destruction of canopy-dwelling invertebrates and the loss of food and/or habitat to fish populations during harvesting operations.
7. Mitigation for unavoidable, extensive, or permanent loss of plant communities should be provided.

5.0 COASTAL/MARINE ACTIVITIES

5.1 Point Source Discharge

Point-source discharges from municipal sewage treatment facilities or storm water discharges are controlled through the EPA's mandated regulations under the Clean Water Act and by state water regulations. The primary concerns associated with municipal point-source discharges involve treatment levels needed to attain acceptable nutrient inputs and overloading of treatment systems due to rapid development of the coastal zone. Storm drains are contaminated from communities with settling and storage ponds, street runoff, and harbor activities. Annually, wastewater facilities through sewage outfall lines introduce large volumes of untreated excrement and chlorine as well as treated freshwater into the nation's waters. This can significantly alter pH levels of marine waters (NPFMC 1999).

Potential Adverse Impacts

There are many potential impacts from point-source discharge, but it is important to note that point-source discharges and resulting altered water quality in aquatic environments does not necessarily result in adverse impacts to either marine resources or EFH. Because most point-source discharges are regulated by the state or EPA, effects to receiving waters are generally considered in those cases. Point-source discharges can adversely affect EFH by 1) reducing habitat functions necessary for growth to maturity, 2) modifying community structure, 3) bioaccumulation, and 4) modifying habitat.

At certain concentrations, point-source discharges can alter the following properties of ecosystems and associated communities: diversity, nutrient and energy transfer, productivity, biomass, density, stability, connectivity, and species richness and evenness. Pollution effects may be related to changes in water flow, pH, hardness, dissolved oxygen, and other parameters that affect individuals, populations, and communities. Sewage, fertilizers, and de-icing chemicals (e.g., glycols, urea) are examples of common urban pollutants that decompose with high biological or chemical oxygen demand (NPFMC 1999).

Point-source discharges, at certain concentrations, can modify by altering the following characteristics of finfish, shellfish, and related organisms: growth, visual acuity, swimming speed, equilibrium, feeding rate, response time to stimuli, predation rate, photosynthetic rate, spawning seasons, migration routes, and resistance to disease and parasites. Additionally, zones of low dissolved oxygen from their decomposition can retard growth of salmon eggs, larvae, and juveniles and may delay or block smolt and adult migration. Sewage and fertilizers also introduce nutrients into urban drainages that drive algal and bacterial blooms which may smother incubating salmon or produce toxins as they grow and die. Thermal effluents from industrial sites and removal of riparian vegetation from streambanks allowing solar warming of water can degrade salmon habitat. Heavy metals, petroleum hydrocarbons, chlorinated hydrocarbons, and other chemical wastes can be toxic to salmonids and their food, and they can inhibit salmon movement and habitat use in streams (NPFMC 1999).

Elevated salinity levels from desalination plants also need to be considered. While these studies have shown that they may not produce toxic effects (Bay and Greenstein 1994), peripheral effects of pollution may include forcing rearing fish into areas of high predation. Conversely, influx of treated freshwater from municipal wastewater plants may force rearing fish into habitat with less than optimal salinity for growth (NPFMC 1999).

Point-discharges may affect the growth, survival and condition of EFH-managed species and prey species if high levels of contaminants (e.g., chlorinated hydrocarbons; trace metals, PAHs, pesticides, and herbicides) are discharged. If contaminants are present, they may be absorbed across the gills or concentrated through bioaccumulation as contaminated prey is consumed (Raco-Rands 1996). Many heavy metals and persistent organic compounds such as pesticides and polychlorinated biphenyls tend to adhere to solid particles discharged from outfalls. As the particles are deposited, these compounds or their degradation products (which may be equally or more toxic than the parent compounds) can enter the EFH foodchain by bioaccumulating in benthic organisms at much higher concentrations than in the surrounding waters (Stein et al. 1995). Due to burrowing, diffusion, and other upward transport mechanisms that move buried contaminants to the surface layers and eventually to the water column, pelagic and nektonic biota may also be exposed to contaminated sediments through mobilization into the water column.

Discharge sites may also modify habitat by creating adverse impacts to sensitive areas such as freshwater shorelines and wetlands, emergent marshes, sea grasses, and kelp beds if located improperly. Extreme discharge velocities of effluent may also cause scouring at the discharge point as well as entrain particulates and thereby create turbidity plumes. These turbidity plumes of suspended particulates can reduce light penetration and lower the rate of photosynthesis and the primary productivity of an aquatic area while elevated turbidity persists. The contents of the suspended material can react with the dissolved oxygen in the water and result in oxygen depletion, or smother submerged aquatic vegetation sites including eelgrass beds and kelp beds. Accumulation of outfall sediments may also alter the composition and abundance of infaunal or epibenthic invertebrate communities (Ferraro 1991). Pollutants, either suspended in the water column (e.g., nitrogen, contaminants, fine sediments) or settled on the bottom, can affect habitat. Many benthic organisms are quite sensitive to grain size, and accumulation of sediments can also submerge food organisms (see Section 4.2.2).

Recommended Conservation Measures

1. Locate discharge points in coastal waters well away from shellfish beds, sea grass beds, coral reefs, and other similar fragile and productive habitats.
2. Reduce potentially high velocities by diffusing effluent to acceptable velocities.
3. Determine benthic productivity by sampling prior to any construction activity related to installation of new or modified facilities. Outfall design (e.g., modeling concentrations within the predicted plume or likely extent of deposition along a productive nearshore), should be developed with input from appropriate resource and Tribal agencies.
4. Provide for mitigation when the degradation or loss of habitat from placement and operation of the outfall structure and pipeline.
5. Institute source-control programs that effectively reduce noxious materials to avoid introducing these materials into the waste stream.
6. Ensure compliance with pollutant discharges regulated through discharge permits which set effluent discharge limitations and/or specify operation procedures, performance standards, or best management practices. These efforts rely on the implementation of best management practices to control polluted runoff (EPA 1993).
8. Discharges should be treated to the maximum extent practicable, including implementation of up-to-date methodologies for reducing discharges of biocides (e.g., chlorine) and other toxic substances.
9. Use land-treatment and upland disposal/storage techniques where possible. Use of vegetated wetlands as natural filters and pollutant assimilators for large-scale discharges should be limited to those instances where other less damaging alternatives are not available and the overall environmental and ecological suitability of such an action has been demonstrated.
10. Avoid siting pipelines and treatment facilities in wetlands and streams. Since pipelines and treatment facilities are not water dependent with regard to positioning, it is not essential that they be placed in wetlands or other fragile coastal habitats. Avoiding placement of pipelines within streambeds and wetlands will also reduce inadvertent infiltration into conveyance systems and retain natural hydrology of local streams and wetlands.

5.2 Fish Processing Waste - Shoreside and Vessel Operation

Seafood processing facilities are either shore-based facilities discharging through stationary outfalls or mobile vessels engaged in the processing of fresh or frozen seafood (SAIC 2001). Discharge of fish waste from shoreside and vessel processing has occurred in marine waters since the 1800s (NPFMC

1999). With the exception of fresh market fish, some form of processing involving butchering, evisceration, pre-cooking or cooking is necessary to bring the catch to market. Precooking or blanching facilitates the removal of skin, bone, shell, gills, and other materials. Depending on the species, the cleaning operation may be manual, mechanical, or a combination of both (EPA 1974). Seafood processing facilities generally consist of mechanisms to offload the harvest from fishing boats; tanks to hold the seafood until the processing lines are ready to accept them; processing lines, process water and waste collection systems; treatment and discharge facilities; processed seafood storage areas; and necessary support facilities such as electrical generators, boilers, retorts, water desalinators, offices, and living quarters. In addition, marinas that cater to patrons who fish a large amount can produce a large amount of fish waste at the marina from fish cleaning.

Potential Adverse Impacts

Generally, seafood processing wastes consist of biodegradable materials that contain high concentrations of soluble organic material. Seafood processing operations have the potential for adversely affecting EFH through 1) direct and/or nonpoint source discharge, 2) particle suspension, and 3) increased turbidity and surface plumes.

Seafood processing operations have the potential for adversely affecting EFH through the direct and/or nonpoint source discharge of nutrients, chemicals, fish by-products, and "stickwater" (water and entrained organics originating from the draining or pressing of steam-cooked fish products). Investigations by the EPA show that impacts affecting water quality are a direct function of the receiving waters. In areas with strong currents and high tidal ranges, waste materials disperse rapidly. In areas of quieter waters, waste materials can accumulate and result in shell banks, sludge piles, dissolved oxygen depressions, and associated aesthetic problems (Stewart and Tangarone 1977). If adequate disposal facilities are not available at marinas that generate a large amount of fish waste, there is a potential for disposal of fish waste in areas without enough flushing to prevent decomposition and the resulting dissolved oxygen depression (EPA 1993).

Processors discharging fish waste are required to have NPDES permits from the EPA. Various water quality standards including those for BOD, total suspended solids (TSS), fecal coliform bacteria (FC), oil and grease, pH, and temperature are all considerations in the issuance of such permits. Although fish waste, including heads, viscera, and bones, is biodegradable, fish parts that are ground to fine particles may remain suspended for some time, thereby overburdening habitats from particle suspension (NPFMC 1999). Such pollutants have the potential to adversely impact EFH. The wide differences in habitats, types of processors, and seafood processing methods define those impacts and can also prevent the effective use of technology-based effluent limits.

In certain areas such as Alaska, seafood processors are allowed to deposit fish parts in a Zone of Deposit (ZOD) (EPA 2001). This can remove benthic habitat from the environment, reduce locally associated invertebrate populations, and lower dissolved oxygen levels in overlying waters. Impacts from accumulated processing wastes are not limited to the area covered by the ZOD. Severe anoxic and reducing conditions occur adjacent to effluent piles (EPA 1979). Examples of localized damage to benthic environment include several acres of bottom-driven anoxic by piles of decomposing waste up to 26 fee (7.9 m) deep. Juvenile and adult stages of flatfish are drawn to these areas for food sources. One effect of this attraction may lead to increased predation on juvenile fish species by other flatfishes, diving seabirds, and marine mammals drawn to the food source (NPFMC 1999). However, due to the difficulty in monitoring these areas, impacts to species can go undetected.

Scum and foam from seafood waste deposits can also occur on the water surface and/or increase turbidity. Increased turbidity decreases light penetration into the water column, reducing primary production. Reduced primary production decreases the amount of food available for consumption by higher trophic level organisms. In addition, stickwater takes the form of a fine gel or slime that can concentrate on surface waters and move onshore to cover intertidal areas.

Recommended Conservation Measures

1. Base effluent limitations on site-specific water quality EFH concerns to the maximum extent practicable.
2. Avoid the practice of discharging untreated solid and liquid waste directly into the environment. Use of secondary or wastewater treatment systems should be encouraged where possible.
3. Designation of new ZODs should not be allowed. Options to eliminate or reduce ZODs at existing facilities should be explored.
4. Control stickwater by physical or chemical methods.
5. Promote sound fish waste management through a combination of fish-cleaning restrictions, public education, and proper disposal of fish waste.
6. Encourage the alternative use of fish processing wastes (e.g., fertilizer for agriculture, and animal feed).
7. Options for additional research should be explored. There is not much current research on which to base management decisions about habitat. Some improvements in waste processing have occurred, but the technology-based effluent guidelines have not changed in 20 years.
8. Locate new plants outside rearing and nursery habitat. Monitor both biological and chemical changes to the site.

5.3 Water Intake Structures/Discharge Plumes

The withdrawal of riverine, estuarine and marine waters by water intake structures is a common aquatic activity. Water may be withdrawn to cool coastal power generating stations, used as a source of water for agricultural purposes, and more recently, as a source of potable water for desalinization plant operations. In the case of power plants and desalinization plants, the subsequent discharge of heated and/or chemically-treated discharge water can also occur.

Potential Adverse Impacts

Adverse impacts to EFH from water intake structures and effluent discharges can interfere or disrupt EFH functions in the source or receiving waters by 1) entrainment, 2) impingement, 3) discharge, 4) operation and maintenance, and 5) construction-related impacts.

Entrainment is the withdrawal of aquatic organisms along with the cooling water into the cooling system. These organisms are usually the egg and larval stages of managed species and their prey. Entrainment can subject these life stages to adverse conditions resulting from the effects of increased heat, antifouling chemicals, physical abrasion, rapid pressure changes, and other detrimental effects. Consequently, diverting water without adequate screening prevents that portion of the EFH from providing important habitat functions necessary for the early life stages of managed living marine resources and their prey. Long-term water withdrawal may adversely affect fish and shellfish populations by adding another source of mortality to the early life stage which often determines recruitment and year-class strength (Travnichek et al. 1993).

Impingement occurs to organisms that are too large to pass through in-plant screening devices and instead become stuck or impinged against the screening device or remain in the forebay sections of the system until they are removed by other means (Grimes 1975, Hanson et al. 1977, Helvey and Dorn 1987, Helvey 1985, Langford et al. 1978, Moazzam and Rizvi 1980). The organisms cannot escape due to the water flow that either pushes them against the screen or prevents them from exiting the intake tunnel. Similar to entrainment, the withdrawal of water can entrapped particular species especially when visual acuity is reduced (Helvey 1985). This condition reduces the suitability of the source waters to provide normal EFH functions necessary for subadult and adult life stages of managed living marine resources and their prey.

Thermal effluents in inshore habitat can cause severe problems by directly altering the benthic community or killing marine organisms, especially larval fish. Temperature influences biochemical processes of the environment and the behavior (e.g., migration) and physiology (e.g., metabolism) of marine organisms (Blaxter 1969). Further, the proper functioning of sensitive areas may be affected by the action of intakes as selective predators, resulting in cascading negative consequences as observed by the overexploitation of local fish populations in coral-reef fish communities (Carr et al. 2002).

Other impacts to aquatic habitats can result from construction related activities (e.g., dewatering, dredging, etc.) (see Section 4.1) as well as routine operation and maintenance activities. There is a broad range of impacts associated with these activities depending on the specific design and needs of the system. For example, dredging activities can cause turbidity, degraded water quality, noise, and substrate alterations. Many of these impacts can be reduced or eliminated through the use of various techniques, procedures, or technologies, but some may not be fully eliminated except by eliminating the activity itself.

In the case of power plants using once-through cooling, biocides such as sodium hypochlorite and sodium bisulfate may used periodically to clean the intake and discharge structures. Chlorine is extremely toxic to aquatic life.

<u>Recommended Conservation Measures</u>

1. Locate facilities that rely on surface waters for cooling in areas other than estuaries, inlets, heads of submarine canyons, rock reefs or small coastal embayments where EFH species or their prey concentrate. Discharge points should be located in areas that have low concentrations of living marine resources. They should incorporate cooling towers to control temperature and employ sufficient safeguards to ensure against release of blow-down pollutants into the aquatic environment in concentrations that reduce the quality of EFH.
2. Design intake structures to minimize entrainment or impingement. Velocity caps that produce horizontal intake/discharge currents should be employed and intake velocities across the intake screen should not exceed 0.5 foot per second.
3. Design power plant cooling structures to meet the “best technology available” requirements (BTAs) as developed pursuant to Section 316(b) of the Clean Water Act. Use of alternative cooling strategies, such as closed cooling systems (e.g., dry cooling) should be used to completely avoid entrainment/impingement impacts in all industries which require cooling water. When alternative cooling strategies prove infeasible, other BTAs may include but are not limited to fish diversion or avoidance systems, fish return systems that convey organisms away from the intake and mechanical screen systems that prevent organisms from entering the intake system, and habitat restoration measures.
4. Regulate discharge temperatures (both heated and cooled effluent) such that they do not appreciably alter the temperature that could cause a change in species assemblages and ecosystem function in the receiving waters. Strategies should be implemented to diffuse the heated effluent.
5. Avoid the use of biocides (e.g., chlorine) to prevent fouling where possible. The least damaging antifouling alternatives should be implemented.
6. Mitigate for impacts related to power plants and other industries requiring cooling water. Mitigation should compensate for the net loss of EFH habitat functions from placement and operation of the intake and discharge structures. Mitigation should be provided for the loss of habitat from placement of the intake structure and delivery pipeline, the loss of fish larvae and eggs that may be entrained by large intake systems, and the degradation or loss of habitat from placement of the outfall structure and pipeline as well as the treated water plume.
7. Treat all discharge water from outfall structures to meet state water quality water standards at the terminus of the pipe. Pipes should extend a substantial distance offshore and be buried deep enough to not affect shoreline processes. Buildings and associated structures should be set well back from the shoreline to preclude the need for bank armoring.

5.4 Oil/Gas Exploration/Development/Production

Offshore exploration, development, and production of natural gas and oil reserves have been, and continues to be, an important aspect of the U.S. economy. As demand for energy resources grows, the debate over trying to balance the development of oil and gas resources and the protection of the environment will also continue. Projections indicate that U.S. demand for oil will increase by 1.3 percent per year between 1995 and 2020. Gas consumption is projected to increase by an average of 1.6 percent during the same time frame (Waisley 1998). Much of the 1.9 billion acres within the offshore jurisdiction of the U.S. remain unexplored (OGTAD 1985). It is also expected that some of the older oil and gas platforms in operation will reach the end of their productive life in the near future. The question of decommissioning is also an issue.

Potential Adverse Impacts

Offshore oil and gas operations can be classified into exploration, development, and production activities. Petroleum exploration/development/production occurs in varying water depths and usually over soft-bottom substrates, although hard-bottom habitats may be present in the general vicinity. These areas are subject to an assortment of physical, chemical, and biological disturbances. These disturbances include 1) noise from seismic surveys, vessel traffic, and construction of drilling platforms or islands, traffic from vessels, 2) physical alterations to habitat from the construction, presence and eventual decommissioning and removal of facilities such as islands or platforms, storage and production facilities, and pipelines to onshore common carrier pipelines, storage facilities, or refineries, 3) waste discharges including well drilling fluids, produced waters, surface runoff and deck drainage, domestic waste waters generated from the offshore facility, solid-waste from wells (drilling muds and cuttings) and other trash and debris from human activities associated with the facility, 4) oil spills, and 5) platform storage, and pipeline decommissioning (NPFMC 1999, Helvey 2002).

Noise sources may generate sound pressure that can disrupt or damage marine life. Oil and gas activities may generate noise from drilling activities, construction, production facility operations, seismic exploration and supply vessel and barge movements (see Section 4.5). The impacts of oil exploration-related seismic energy releases may interrupt and cause fish to disperse from the acoustic pulse with possible disruption to their feeding patterns. It is known that noise in the marine environment may adversely affect marine mammals by causing them to change behavior (movement, feeding), interfere with echolocation and communication, or may result in injury to hearing organs (Richardson et al. 1995). Activities such as vessel anchoring, platform or artificial island construction, pipeline laying (see Section 4.10), dredging, and pipeline burial can alter bottom habitat by altering substrates used for feeding or shelter. Disturbances to the associated epifaunal communities, which may provide feeding or predator escape habitat, can also result. Benthic organisms, especially prey species, may recolonize disturbed areas, but this may not occur if the composition of the substrate is drastically changed or if facilities are left in place after production ends. Dredging, trenching and pipelaying generate spoils that may be disposed of on land or the marine environment where sedimentation may smother benthic habitat and organisms. Most of these activities associated with oil and gas operations, however, are conducted under permits and regulations that require companies to minimize impacts or to avoid construction or other disturbances in sensitive marine habitats (see Section 4.2.2).

The discharge of drilling muds and cuttings can result in varying degrees of change on the sea floor and affect feeding, nursery, and shelter habitat for various life stages of managed species. Drilling muds and cuttings may adversely affect bottom-dwelling organisms at the site by burial of immobile forms or forcing mobile forms to migrate. Exploratory and construction activities may also result in resuspension of fine-grained mineral particles, usually smaller than silt, in the water column. These suspended particulates can reduce light penetration and lower the rate of photosynthesis and the primary productivity of the aquatic area especially if suspended for lengthy intervals. Groundfish and other fish species can suffer reduced feeding ability leading to limited growth if high levels of suspended particulates persist. The contents of the suspended material can react with the dissolved oxygen in the water and result in oxygen depletion. In addition, the discharge of oil drilling muds can change the chemical and physical characteristics of benthic sediments at the disposal site by introducing toxic chemical constituents. Changes in the clarity and the addition of contaminants can reduce or eliminate the suitability of water bodies as habitat for fish species and their prey (NMFS 1998).

Oil spills are a serious potential source of contamination to the marine environment from oil and gas development. Offshore oil and gas development will inevitably result in some oil entering the environment. Most spills are expected to be of small size, although there is a potential for large spills to occur. Many factors determine the degree of damage from a spill, including the type of oil, size and duration of the spill, geographic location of the spill, and the season. Although oil is toxic to all marine organisms at high concentrations, certain species are more sensitive than others. In general, the early life stages (eggs and larvae) are most sensitive, juveniles are less sensitive, and adults least so (Rice et al. 2000).

In whatever quantities, lost oil can affect habitats and living marine resources. Accidental discharge of oil can occur during almost any stage of exploration, development, or production on the outer continental shelf (OCS) or in nearshore coastal areas. Oil spills can occur from many possible sources including equipment malfunction, ship collisions, pipeline breaks, other human error, or severe storms. Oil spills can also be attributed to support activities associated with product recovery and transportation. In addition to crude oil spills, chemical, diesel, and other contaminant spills can occur with OCS activities (NPFMC 1999).

Chronic small oil spills are a potential problem because residual oil can build up in sediments and affect living marine resources. Low levels of petroleum components (polycyclic aromatic hydrocarbons- PAH) from such chronic pollution can accumulate in salmon tissues and cause lethal and sublethal effects, particularly at the embryo stage. Effects on fish from low-level chronic exposure may increase embryo mortality, reduce marine growth (Heintz et al. 2000), or increase straying away from natal streams by returning adults (Wertheimer et al. 2000).

It is possible for a major oil spill (i.e., 50,000 barrels) to produce a surface slick covering up to several hundred square kilometers of surface area. If the oil spill moves toward land, habitats and species could be affected by the loading of oil into the near shore environment. In the initial hours after a large spill, aromatic hydrocarbons would generally be at toxic levels to some organisms. Beneath and surrounding the surface slick, there would be some oil-contaminated waters. Physical and biological forces act to reduce oil concentrations with depth and distance (NPFMC 1999); generally the lighter fraction aromatic hydrocarbons evaporate rapidly, particularly during periods of high wind and wave activity. Heavier oil fractions may settle through the water column. Suspended sediment can adsorb and carry oil to the seabed. Hydrocarbons may be solubilized by wave action which may enhance adsorption to sediments, which then sink to the seabed, contaminating benthic sediments. Carls et al. (2003) demonstrated that tides and the resultant hydraulic gradients provide a mechanism for groundwater transport of soluble and slightly soluble contaminants (such as oil) from beaches surrounding streams into the hyporheic zone where pink salmon eggs incubate. Oil may reach nearshore areas and affect productive nursery grounds or areas containing high densities of fish eggs and larvae. An oil spill near an especially important habitat (e.g., a gyre where fish or invertebrate larvae are concentrated) could also result in a disproportionately high loss of a population of marine organisms. Other aquatic biota at risk would be eggs, larvae and other planktonic organisms in the upper seawater column. Because they cannot actively avoid exposure, their small size means they absorb contaminants quickly, and their proximity to the seasurface means they may be vulnerable to photo-enhanced toxicity effects, which can increase the toxicity of hydrocarbons several fold (Barron et al. 2003). In addition, oil spills may interrupt commercial or subsistence fishing activities.

Habitats that are susceptible to damage from spill oil include not just the low energy coastal bays and estuaries where oil may accumulate but also high energy cobble environments where oil is driven into sediments through wave action. Many of the beaches in Prince William Sound with the highest persistence of oil following the *Exxon Valdez* oil spill were high-energy environments containing large cobbles overlain with boulders. These beaches were pounded by storm waves which drove the oil into and well below the surface (Michel and Hayes 1999). Oil that mixes into bottom sediments can persist for years. Subsurface oil was still detected in beach sediments of Prince William Sound 12 years after the *Exxon Valdez* oil spill, much of it unweathered and more prevalent in the lower intertidal biotic zone than at higher tidal elevations (Short et al. 2002). Additional concern is the unknown impact of an oil-related event near and/or within ice. The water column adjacent to the ice edge is stable. This stabilization (or stratification) would allow relatively quick transport of oil to the sea floor. Additionally, oil trapped in ice could impact habitat significantly after the initial event, months or years later, and even into a different region (NPFMC 1999).

Residual oil from a spill can remain toxic for long periods. Petroleum is a complex mixture of alkanes and aromatic hydrocarbons, of which the alkyl-substituted and multi-ring PAHs are the most toxic and persistent. Following weathering, the aromatic fraction of oil is dominated by PAHs as the lighter aromatic components evaporate or are degraded. Because of low solubility in water, the large PAH concentrations probably contribute little to acute toxicity of oil-water solutions. Lipophilic PAH, however, may cause physiological injury if it accumulates in tissues after exposure (Carls et al. 1999, Heintz et al. 2000). Also, even when concentrations of oil are sufficiently diluted not to be physically damaging to marine organisms, it still may be detected by them, and may alter certain behavior patterns.

Oil and gas platforms may be comprised of a lattice-work of pilings, beams and pipes that support diverse fish and invertebrate populations and are considered de facto artificial reefs (Love and Westphal 1990, Love et al. 1994, Love et al. 1999, Helvey 2002). Because decommissioning includes plugging and abandoning all wells and removing the platforms and associated structures from the ocean, impacts to EFH can result during removal. Impacts during the demolition phase may include underwater sound pressure waves (see Section 4.5.1) and impacts on marine organisms; removal of structures may remove habitat for invertebrates and fish that associate with midwater structures. In some areas of the U.S., offshore oil and gas platforms are allowed to remain after decommissioning, thereby providing permanent habitat for some organisms.

The potential disturbances and associated adverse impacts on the marine environment has been reduced through the operating procedures required by regulatory agencies and in many cases self imposed by facilities operators. Most of the activities associated with oil and gas operations are conducted under permits and regulations that require companies to minimize impacts or avoid construction in sensitive marine habitats. New technological advancements result in improved operating practices reducing the potential for impacts. For example the discharge of muds and cuttings is being phased out of modern oil and gas production programs; generally such byproducts of exploration or development are ground into finer materials and injected into wells that penetrate subsea reservoir strata and do not enter the marine environment.

Recommended Conservation Measures

Oil and gas exploration, development, and production can be conducted in a manner that minimizes adverse impacts on the marine environment. Over the past several decades, government agencies and petroleum production companies have developed operating procedures that reduce potential adverse effects; these procedures are generally required through permits. The following are recommended measures that should be considered in permitting future oil and gas operations.

1. Conduct pre-project biological surveys in consultation with NMFS to determine the extent and composition of biological populations or habitat in the proposed production area. On the basis of the site-specific surveys a determination will be made whether or not the operations are likely to have an adverse effect upon EFH, or that a special biological population/habitat does not exist. Based on the information in the surveys, the following may be recommended:
    a. Redesign facilities to accommodate habitat concerns.
    b. Operate during those periods of time, as established in consultation with NMFS, that do not adversely affect biological resources.
    c. Modify operations to ensure that significant biological populations or habitats deserving protection are not affected.
2. Limit the discharge of produced waters into marine and estuarine environments. Re-inject produced waters into the oil formation whenever possible.
3. Avoid discharge of muds and cuttings into the marine and estuarine environment. Use methods to

grind and re-inject such wastes down an approved injection well or use onshore disposal wherever possible. When not possible, provide for a monitoring plan to quantitatively assess whether effluent discharges are meeting the needs of EFH.
4. Limit placement of causeways or structures in the nearshore marine environment.
5. Encourage the use of geographic response strategies that identify EFH and environmentally sensitive areas and identify appropriate cleanup methods to include the prestaging of response equipment.
6. Use methods to transport oil and gas that limit the need for handling in environmentally sensitive areas, including EFH.
7. Prohibit drilling of the first development well into the targeted hydrocarbon formations during hazardous or sensitive environmental conditions, such as broken ice.
8. Prohibit drilling of exploration wells into untested formations during hazardous or sensitive environmental conditions.
9. Provide for monitoring and leak detection systems that preclude oil and gas from entering the environment.
   a. Utilize systems that detect spills and leaks as rapidly as technologically possible so that action can be taken to avoid or reduce the effect to EFH, and
   b. Utilize maximum precautions to eliminate pipeline failure caused by external forces.
10. Evaluate impacts to habitat during the decommissioning phase, including impacts during the demolition phase and impacts resulting from permanent habitat losses.

5.5 Habitat Restoration/Enhancement

Habitat loss and degradation are major, long-term threats to the sustainability of fishery resources (NOAA Fisheries 2002). Viable coastal and estuarine habitats are important to maintaining healthy fish stocks. Good water quality and quantity, appropriate substrate, ample food sources and substantial hiding places are needed to sustain fisheries. Restoration and/or enhancement of coastal and riverine habitat that supports managed fisheries and their prey will assist in sustaining and rebuilding fisheries stocks and recovering certain threatened or endangered species by increasing or improving ecological structure and functions. Habitat restoration/enhancement may include, but is not limited, to improvement of coastal wetland tidal exchange or reestablishment of historic hydrology; dam or berm removal; fish passage barrier removal/modification; road related sediment source reduction; natural or artificial reef/substrate/habitat creation; establishment or repair of riparian buffer zones and improvement of freshwater habitats that support anadromous fishes; planting of native coastal wetland and submerged aquatic vegetation; creation of oyster reefs; and improvements to feeding, shade or refuge, spawning and rearing areas that are essential to fisheries.

Potential Adverse Impacts

The implementation of restoration/enhancement activities may have localized and temporary adverse impacts on EFH. Possible impacts can include 1) localized nonpoint source pollution such as influx of sediment or nutrients, 2) interference with spawning and migration periods, 3) temporary or permanent removal feeding opportunities; and 4) indirect effects from actual construction portions of the activity.

Unless proper precautions are taken, upland related restoration projects can contribute to nonpoint source pollution. Such concerns should be addressed as part of the planning process (see Section 2.1). Particular in-water projects may interfere with spawning periods or impede migratory corridors and should be addressed accordingly. Projects may also have an effect on the feeding behavior of managed species. For instance, if dredging is involved, benthic food resources may be impacted. (See also Section 4.1). Impacts can occur from individuals conducting the restoration, especially at staging areas, as part of accessing the restoration site, or the actual restoration techniques employed. Particular impacts can result from water quality impacts from individuals conducting the restoration, excessive foot traffic, diving techniques, equipment handling, boat anchoring, and planting techniques.

The use of artificial reefs is a popular form of habitat enhancement, but it can also impact the aquatic environment through the loss of habitat upon which the reef material is placed or the use of inappropriate materials in construction. Usually, reef materials are set upon flat sand bottoms or “biological deserts” which end up burying or smothering bottom-dwelling organisms at the site or even preventing mobile forms (e.g., benthic-oriented fish species) from utilizing the area as habitat. Some materials may be inappropriate for the marine environment (e.g., automobile tires; compressed incinerator ash) and can serve as sources of toxic releases or physical damage to existing habitat when breaking free of their anchoring systems (Collins et al. 1994).

Recommended Conservation Measures

1. Use BMPs to minimize and avoid all potential impacts to EFH during restoration activities. This conservation measure requires the use of BMPs during restoration activities to reduce impacts from project implementation. BMPs should include, but are not limited to, the following:
   a. Measures to protect the water column—Turbidity curtains, haybales, and erosion mats should be used.
   b. Staging areas—Areas used for staging will be planned in advance and kept to a minimum size.
   c. Buffer areas around sensitive resources—Rare plants, archeological sites, etc., will be flagged and avoided.
   d. Invasive species—Invasive plant and animal species should be removed from the proposed action area prior to commencement of work. Only native plant species should be planted. Measures to ensure native vegetation or revegetation success will be identified and implemented (see also Section 4.4).
   e. Ingress/egress areas—Temporary access pathways will be established prior to restoration activities to minimize adverse impacts from project implementation.
2. Avoid restoration work during critical fish windows to reduce direct impacts to important ecological functions such as spawning, nursery, and migration. This conservation measure requires scheduling projects when managed species are not expected in the area. These periods should be determined prior to project implementation to reduce or avoid any potential impacts.
3. Provide adequate training and education to volunteers and project contractors to ensure minimal impact to the restoration site. Volunteers should be trained in the use of low-impact techniques for planting, equipment handling, and any other activities associated with the restoration. Proper diving techniques need to be used by volunteer divers.
4. Conduct monitoring before, during, and after project implementation to ensure compliance with project design and restoration criteria. If immediate post-construction monitoring reveals that unavoidable impacts to EFH have occurred, appropriate coordination with NOAA Fisheries should occur to determine appropriate response measures, possibly including mitigation.
5. Mitigate fully any unavoidable damage to EFH during project implementation and accomplish within reasonable period of time after the impacts occurred.
6. Remove and restore, if necessary, any temporary access pathways and staging areas used in the restoration effort.
7. Determine benthic productivity by sampling prior to any construction activity in the case of subtidal enhancement (e.g., artificial reefs). Areas of high productivity should be avoided to the maximum extent possible. Sampling design should be developed with input from state and federal resource agencies. Prior to construction, an evaluation of the impact resulting from the change in habitat (sand bottom to rocky reef, etc.) should be performed. Post-construction monitoring should examine the effectiveness of the structures for increasing habitat productivity.

5.6 Marine Mining

Mining activity, as also described in Section 3.1.1 and Section 3.1.2, can lead to the direct loss of EFH for certain species. Offshore mining as well the mining of gravel from beaches, can increase turbidity of water and, thus, the resuspension of organic materials could affect less motile organisms (i.e., eggs and recently hatched larvae) in the area. Benthic habitats could be damaged or destroyed by these actions. Mining of large quantities of beach gravel can significantly affect the removal, transport, and deposition of sand and gravel along the shore, both at the mining site and down current (NPFMC 1999). Neither the future extent of this activity nor the effects of such mortality on the abundance of marine species is known.

Potential Adverse Impacts

Mining practices that can impact EFH include physical impacts from intertidal dredging and chemical impacts from the use of additives such as flocculates (NPFMC 1999). Impacts include the removal of substrates that serve as habitat for fish and invertebrates; creation (or conversion) of areas to less productive or uninhabitable sites such as anoxic holes or silt bottom; burial of productive habitats, such as in near shore disposal sites (as in beach nourishment); release of harmful or toxic materials either in association with actual mining, or in connection with machinery and materials used for mining; creation of harmful turbidity levels; and adverse modification of hydrologic conditions so as to cause erosion of desirable habitats. Submarine disposal of mine tailings can also alter the behavior of marine organisms. Submarine mine tailings may not provide suitable habitat for some benthic organisms. In laboratory experiments, benthic dwelling flatfishes (Johnson et al. 1998b) and crabs (Johnson et al. 1998a) strongly avoided mine tailings.

During beach gravel mining, water turbidity increases and the resuspension of organic materials can affect less motile organisms (i.e., eggs and recently hatched larvae) in the area. Benthic habitats can be damaged or destroyed by these actions. Changes in bathymetry and bottom type may also cause alteration in population and migrations patterns (Hurme and Pullen 1988).

Recommended Conservation Measures

1. Avoid mining in waters containing EFH.
2. Minimize the areal extent and depth of extraction to minimize recolonization times.
3. Limit sand mining and beach nourishment in areas with EFH.
4. Monitor turbidity during operations and cease operations if turbidity exceeds predetermined threshold levels. Use sediment or turbidity curtains to limit the spread of suspended sediments and minimize the area affected.
5. Monitor the number of individual mining operations to avoid and minimize cumulative impacts. For instance, three mining operations in an intertidal area could impact EFH, whereas one may not. Also, disturbance of previously contaminated mining areas threaten an additional loss of EFH.

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8.0 INDEX

Appendix 15

Organizations contacted for information on non-fishing impacts to EFH

Contact	Organization	Comments	Contact Recommendations
NOAA/NMFS			
Russ Strach NMFS NW Region EFH Coordinator 503-231-6266	NMFS	*To his knowledge, there is no GIS data available *Recommends using data rich areas (I.e. Willapa) as example of possibilities *Especially important non-fishing impacts on west coast: dredging gravel mining sediment contamination shoreline development	Barb Seekins - EFH GIS Analyst 503-736-4739
Mark Helvey NMFS SW Region EFH Coordinator 562-980-4046	NMFS		
Barb Seekins EFH GIS Analyst 503-736-4739 barbara.seekins@noaa.gov	NOAA	*To her knowledge, there is no readily available NFI data. She is researching a similar question next week and will let me know if she finds anything. I e-mailed a follow-up.	Dredging: Don Easedale ACE GIS Analyst Estuary HazMat: Jill Peterson 206-526-6944 Montery Bay Research Institute - no number
Jill Peterson Estuary HazMat 206-526-6944	NOAA	*Has Environmental Sensitivity Maps for California available digitally, nothing for Oregon. Washington State was done in the mid-eighties so it is available in hard copy. Currently doing the Columbia River.	George Graettinger - NMFS GIS Analyst 206-526-4660
George Graettinger 206-526-4660	NOAA	message 10-2	
Ken Buja 301-713-3028 National Status and Trends	NOAA	They do not have any human impact data, they focus on biological information	call Nancy Wright at CDF&G
EPA			
Bill Bogue 206-553-1676 bogue.william@epa.gov	EPA	*He is the GIS analyst in charge of Coastal issues, and to his knowledge they do not have any NFI information available. Because the State offices in Washington and Oregon are so strong, EPA takes a back seat.	Lorraine Edmond EPA Coastal EMAP - 206-553-7366 Wash & Oregon DOE and DEQ have facility information
Lorraine Edmond 206-553-7366 EPA Coastal EMAP	EPA	Began sampling small estuaries in 1999, large estauries in 2000. Looking at water quality, sediment and fish (by trawling). Recommended National Coastal Condition Health Report. www.epa.gov/owow/oceans/NCCR/index and www.epa.gov/r10earth/emap.htm	California

Contact	Organization	Comments	Contact Recommendations
ARMY CORPS OF ENGINEERS			
Dan Specht 415-977-8591	USACE Northern California	Has dredging information (see data sheet). He is new to the job so he is just beginning to pull together information. There is no coastwide dataset. Most data they have are at the single project level. Responsible for navigable waters only. Although they regulate some mining in navigable waters, no GIS coverage available. Database is available, but few permits are in it.	need to contact each regional ACE office for same information Puget Sound
Jim Francis 503-808-4856 GIS Analyst	USACE Portland District	Has dredge site surveys in microstation - he will look into if anything is in ArcView. He'll call back with what exactly they have.	Mark Siipola - he does sediment testing at disposal sites. 503-808-4885
Doug Swanson 503-808-4856 GIS Analyst	USACE Portland District - Jan 26	will look into dredge and fill data and get back to me	keep calling
Lauren Cole-Warner 206-764-6550	USACE Seattle District	Part of the Regional sediment evaluation team	David Kendall 206-764-3768
David Kendall 206-764-3768	USACE Seattle District	pointed me to the bi-annual report containing dredge and fill sites on their web page. www.usace.army.mil	maybe David Fox can help get digital data to us. 206-764-6083
David Fox 206-764-6083	USACE Seattle District GIS Analyst	e-mail request and he will see if he can help - extremely limited resources. E-mail sent 1-29-04	david.f.fox@usace.army.mil
Jeff Dorsey 503-808-4769	USACE Portland District	phone tag, last message left 1-30	
Miscellaneous			
Bob Euliss 360-902-3015	Office of the Interagency Committee for Outdoor Recreation (IAC)	Have marina and boat launch data available for public facilities only. There is no database containing private marinas.	
Liam Intellman 360-457-6622	Olympic Coast National Marine Sanctuary	primarily site specific information, but gave contact names	fiber optics: ACE regulates at state level OR Fisherman's Cable Committee - Scott McMullen 503-325-2285 CA Coastal Commission - Maria Kavanaugh 541-737-5359 Helen Berry - Shoreline hardening in shorezone database
Scott McMullen 503-325-2285	OR Fisherman's Cable Committee	this group is the first stop for cable applicants in Oregon. 5 cables laid in OR, another this winter. CA has approx. 20 cables and WA has 3 (not including Navy). As far as he knows, there is no centralized government GIS database containing cable locations.	www.ofcc.com is his web page, www.iscpc.org should be reviewed for private companies that may have cable locations mapped and for sale. ***called again January 30 and Scott said he would send me lat/longs for the 6 cables off Oregon Coast (5 current and 1 proposed)

Contact	Organization	Comments	Contact Recommendations
Maria Kavanaugh 541-737-5359	California Coastal Commission	message	
Debra Wolcott 805-389-7627	Minerals Management Service Information Technology		79 active leases (470 issued) in the pacific, call janice hall to get info 805-389-7621
Janice Hall 805-389-7621	Minerals Management Service Information Technology	message 1-16, 1-23	
Boyd Bosserman 303-275-7127	Minerals Management Service Mapping and Boundary Branch	Maps and GIS data of the MMS Offshore Leasing Program	
Dorcie Sarantos 401.243.8114	KMI Optical Networking Intelligence	inquired to see if they sell digital information on west coast cable location - information pending	
Henry Hale 1 877 579 0218 hhenry@primetrica.com	PriMetrica, Inc.	have hard copy cable information for purchase, he is looking into getting digital information for us. Sent e-mail to him with our requirements.	
Tanya Haddad 503.731.4065 ext. 30 tanya.haddad@state.or.us	Oregon Ocean-Coastal Management Program Oregon Department of Land Conservation & Development	message	
Bob Wargo (973) 326-3398 rwargo@att.com	AT&T	Scott McMullen suggested I contact Bob - he's the Chair of the North America Submarine Cable Association. Thought he could get me cable location for CA and WA	
Jody Gianini 805-771-9638	Central California Joint Cable/Fisheries Liason Committee		**www.fiberfish.org has 5 cable locations**
Robin Downey (360) 754-2744	Pacific Shellfish Growers Association	Location data for aquaculture sites not available. Dept of Health has info available in huge blocks of available areas, but not what is actually being farmed (which is a small percentage of available area). There are 300 active farms in Washington State. WDFW does have an Aquatic Farm Registry but is extremely inaccurate.	Contacts: Bob Woolrich (DOH) 360-236-3329

Contact	Organization	Comments	Contact Recommendations
Washington State			
Michele Robinson 360-249-1211	WA DFW Marine Resources Division	they have no NFI type data, they do regulate shellfish beds, call for info	Olympic National Marine Sanctuary (Carol Burnthal)360-457-6622 Dan Ayers - WA DFW shellfish guy 360-249-1209 Rebecca Post - WA DOE 360-407-7114 Roy Peterson - WA DOE 360-407-7202
Dan Ayers 360-249-1209	WA DFW Marine Resources Division (shellfish)	message	
Rebecca Post 360-407-7114	WA DOE	message 10-10	
Roy Peterson 360-407-7202	WA DOE	message 10-10	
Sharon O'Conner 360-407-6142	WA DOE	if anyone has water quality information (point source and non-point source) DOE is the agency. She will ask around and call me back.	
Stephen Burneth (360) 407-6459	WA DOE	not much on non-point source pollution. USGS LULC best available. They have facility information, but not outfall info. No-one's done anything on the coast - work has focused on Puget Sound.	
Andrea Copping 206-685-8209	Sea Grant	Invasive species: no comprehensive database available. Need tolook at species impacting areas, Spartina is the big invasive in the NW. In SF Bay, Benthic Organisms are the biggest problem. Aquaculture: commercial sites will have big effect on EFH, need to map culture locations Water Quality: 303(d) may be best legally defensible source, but big problems with data. Recommends combining ambient water quality data with sediment info.	Contacts: Invasive species - Scott Smith WDFW 360-902-2724 Aquaculture: Robin Downey, Pacific Coast Shellfish Growers Association Water Quality: Jan Newton (DOE) 360-407-6675
Scott Smith 360-902-2724	WA DFW Invasive Species Coordinator	message 1-30	
Helen Seyferlich 360-236-3323	WA Department of Health Shellfish Division	She is completing a GIS database of all active shellfish farms in Washington State. Will send it next week. Call to follow up.	**Call to follow up.**
Bob Woolrich 360-236-3329	Washington State Department of Health	only have fecal coliform and temp data for Willapa and Grays Harbor. Nothing on the Coast.	

Contact	Organization	Comments	Contact Recommendations
California/Oregon State			
"Mira" 831.649.2942	DFG CA GIS Lab - Marine Conservation		sending e-mail with link to web site with available data and other contact information (Oct 10)
Ivan Comacho 503-229-5088	OR DEQ GIS Lab	phone tag	
Mark Charles 503-229-5589	OR DEQ NPS Control Program	message october and january 16, mark returned call 1-22, I left message 1-23	
Jack Gregg 415-904-5246	California Coastal Commission NPS/Water Quality Program	Non-point source data is not readily available for the state, altho there is some localized data for areas such as the San Francisco Bay. There is a statewide water quality snapshot developed by the public for one day in 2003, but it is a volunteer-based effort with only one day's data. Even this agency is working at the small scale and does not have a statewide database.	point source data may be available for the state water board.
Frank Schnitzer 541-967-2039 x25	OR Dept of Geology	phone tag - last message 1-23, 1-30	
USGS			
Cynthia Barton 253-428-3600 ext: 2602	USGS - NW Contact	Efforts on west coast have focused on a handful of watersheds (Sacramento, Willamette, SF Bay, LA, Puget Sound). Need to call National office for coarser LULC data available coastwide.	Vicky Lucas (Washington contact) 206-220-4567 Rick Harris (California contact) 916-278-3021
Rick Hines 916-278-3021	USGS - California Water Resources Coordinator	They do have watershed LULC data available, speak with GIS folks	Donna Knifong 916-278-3081
Donna Knifong 916-278-3081	USGS - California GIS Analyst	have early 1990's satellite LULC data, basic classification (orchards, forested, urban, etc)	contact Naomi Nakagaki 916-278-3092
Naomi Nakagaki 916-278-3092	USGS -National GIS Analyst	have early 1990's satellite LULC data, 30m resolution, she will send	

Appendix 16

Introduction to Bayesian Network Models

1.1 Network models

1.1.1 Why Network Models?

Traditional statistical modeling defines and builds models for a response (outcome) in terms of sets of explanatory variables (attributes). Each explanatory variable in a model is seen as *directly* impacting on the response variable. With explanatory variables $x_1, x_2, \ldots, x_p$, and response y, the situation can be represented by the diagram in
Figure 1.

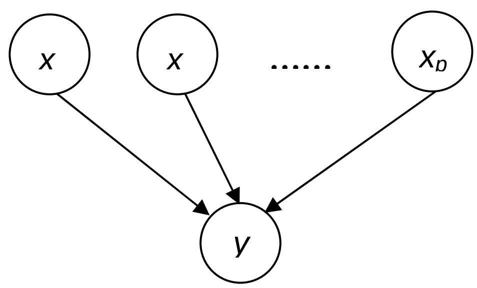

Figure 1 . Explanatory variables directly impacting on a response variable.

In reality, however, it can happen that the relationships between variables are not as simple as this model allows. The effect of one *x*-variable on the response *y* may be mediated through another *x*-variable, or through two or more *x*-variables. It could also happen that some of the *x*-variables affect some of the others. Indeed, with datasets containing many variables, it is easy to envisage quite complex patterns of association. The roles of “response” and “explanatory” become blurred, with variables taking on each role in turn. In a simple example, illustrated in Figure 2, variables *E* and *D* could be regarded as “responses”, and *A* and *B* as “explanatory.” But *C* seems to play both roles. It looks like a response with *A* and *B* acting as explanatory variables, and it is an “explanatory” variable for *E*. The variables are modeled as random variables and the links are probabilistic. A link from *A* to *C* would be interpreted as meaning that the value of *A* affects the value of *C* by means of influencing the probability distribution of *C*.

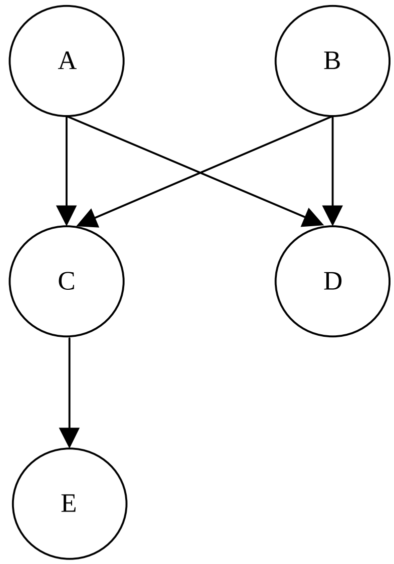

Figure 2. Indirect mediation of effects of explanatory variables.

Historically, these models evolved largely in the artificial intelligence (AI) community, and form the basis of *expert systems*. Generally they are not tools for statistical inference but rather they are mechanisms for encoding probabilistic causal relationships and making predictions from them. Because of their AI background, it is not surprising that the current terminology of network models is quite different from statistical terms, and is perhaps less familiar. Sometimes there is an exact correspondence between an AI term and a statistical one, the two terms being different names for the same concept.

1.1.2 Bayesian Networks

Early applications of Bayesian networks (BN) were in medical diagnosis and genetics, but recently there has been an explosion in their use, including for environmental impact assessment, tracing faults in computer systems and software, robotics, and many other areas (see Appendix 6B for sources of information on BNs). A growing area of interest is the management of natural resources under uncertainty. For example, a BN model was developed for assessing the impacts of land use changes on bull trout populations in the USA (Lee 2000). Another recent application of BNs is modeling uncertainties in fish stock assessment and the impact of seal culling on fish stocks (Hammond & O'Brien 2001). Marcot *et al*. (2001) have used BNs for evaluating population viability under different land management alternatives, while Wisdom *et al*. (2002) used BNs in conservation planning for the greater sage-grouse.

The network models that we are using consist of a number of *nodes* (random variables) connected by *directed* links. A node that has a directed link leading from it to another node is called a *parent* node; the latter is a *child* node. Cycles are not permitted: that is, it is not possible to start from any node and, following the directed links, end up back at the same node. Most of the currently available software for building and analyzing BNs requires that the nodes are discrete, taking only a finite set of possible values, and we assume this to be the case in what follows. Continuous variables can be accommodated by grouping their values into class intervals. An introductory account of BNs is given by Jensen (1996) while a more rigorous and complete treatment is Cowell *et al*. (1999).

To explain the basic ideas, consider the simple example from Figure 2. For simplicity, assume that all of the nodes are binary variables, taking values T or F (true or false). The probabilistic mechanism that governs the relationship between, say, *E* and its parent *C* is the *conditional probability distribution* of *E* given *C*. This can be expressed as a table:

	E	
C	*F*	*T*
F	p_{00}	p_{01}
T	p_{10}	p_{11}

The table of conditional probabilities for node *C*, which has parents *A* and *B*, would have the following form:

		C	
A	*B*	*F*	*T*
F	*F*	p_{000}	p_{001}
F	*T*	p_{010}	p_{011}
T	*F*	p_{100}	p_{101}
T	*T*	p_{110}	p_{111}

A node with no parents (*A* or *B* in the example) would have just a *prior* probability table:

A	
F	*T*
p_0	p_1

The complete specification of a BN consists of

(a) the set of nodes,
(b) the directed causal links between the nodes,
(c) the tables of conditional probabilities for each node.

1.1.3 Estimating the Conditional Probabilities

In practice, there are several possible ways of obtaining estimates for the conditional (and prior) probabilities. If sufficient data are available then cross-tabulating each node with its parents should produce the estimates. There are alternatives to deriving the probabilities from data, however. It is possible to use *subjective* probabilities or *degrees of belief*, usually encoded from expert opinions. In many of the early applications of BNs in medical diagnosis this was generally the approach that was used. There has been some recent research into developing systematic ways of *eliciting* prior beliefs from experts and building probability distributions from them (O'Hagan 1998).

1.1.4 Evidence and Updating

In the simple example of Figure 3, if the states of the nodes (i.e. the values of the variables) *A* and *B* were known, then it would be possible to use the rules of probability to calculate the probabilities of the various combinations of values of the other nodes in the network. This kind of reasoning in a BN can be called "prior to posterior," in the sense that the reasoning follows the directions of the causal links in the network. Suppose now that the state of node *E* were known. What could be said about the other nodes? The *updating algorithm* of Lauritzen and Spiegelhalter (1998) allows us to calculate the posterior probabilities of all other nodes in the network (and this works for *any* BN), given the known value at *E*, or indeed, given any combination of known nodes. In the jargon of expert systems, "knowing" the value of a node is called "entering evidence." This is "posterior to prior" reasoning and allows us to infer something about the states of nodes by reasoning *against* the direction of the causal links. The updating algorithm is a very powerful tool in BNs and enables us to make useful predictions and examine "what if" scenarios with ease. Various software packages are available which facilitate the construction of BNs and implement the updating algorithm. For this project, we are using the program Netica (Norsys 1998).

2 REFERENCES

Cowell R.G., Dawid A.P., Lauritzen S.L., Spiegelhalter D.J. (1999) *Probabilistic Networks and Expert Systems*. Springer, New York.

Hammond T.R. and C.M. O'Brien. (2001) An application of the Bayesian approach to stock assessment model uncertainty, *ICES J. Marine Science* **58**, 648-656.

Jensen F.V. (1996) *An Introduction to Bayesian Networks*. Springer, New York.

Lauritzen S.L., Spiegelhalter D.J. (1998) Local computations with probabilities on graphical structures and their application to expert systems (with discussion). *Journal of the Royal Stat. Soc.B*, **50**, 157-224.

Lee D.C. (2000) Assessing land-use impacts on bull trout using Bayesian belief networks, in Ferson, F., Burgman M. *Quantitative Methods in Conservation Biology*, Springer, New York.

Marcot, B. G., R. S. Holthausen, M. G. Raphael, M. Rowland, and M. Wisdom. (2001) Using Bayesian belief networks to evaluate fish and wildlife population viability under land management alternatives from an environmental impact statement. *Forest Ecology and Management* **153**, 29-42.

Norsys Software Corp. (1998) *Netica*. www.norsys.com/netica

O'Hagan A. (1998) Eliciting expert beliefs in substantial practical applications. *The Statistician* **47** Part 1, 21-35.

Wisdom, M.J., Wales, B.C., Rowland, M.M., Raphael, M.G., Holthausen, R.S., Rich, T.D., Saab, V.A. (2002) Performance of Greater Sage-Grouse models for conservation assessment in the Interior Columbia Basin, USA. *Conservation Biology* **16**, 1232-1242.

Appendix 17

Useful websites on Bayesian Belief networks

General theory of network and other graphical models, with links to other sites
http://www.ai.mit.edu/~murphyk/Bayes/bnintro.html

Software products for creating network models
http://bayes.stat.washington.edu/almond/belief.html

Website for Bayes Net project
http://www.cs.orst.edu/~dambrosi/bayesian/frame.html

Genie product
http://www2.sis.pitt.edu/~genie

Netica product
www.norsys.com

Hugin product
www.hugin.com

Microsoft belief network Product
http://www.research.microsoft.com/dtg/msbn

Online tutorial for Bayesian inference and modeling
http://b-course.cs.helsinki.fi/

Appendix 18

Identification of Essential Fish Habitat for the Pacific Groundfish FMP

Development of Profiles of Habitat Suitability Probability based on latitude and depth for species and life stages in the Groundfish FMP

Table of Contents

1 SUMMARY

The objective for this analysis was to produce habitat suitability probability tables given latitude in decimal degrees and depth in meters for as many of the species and life stages in the Groundfish FMP as possible. There are 82 species in the FMP. Considering four life history stages for each (eggs-larvae-juveniles-adults) makes a total of a possible 328 profiles. In reality, there were data available for less than half of these. At the end of the analysis, all adult phases were covered, 48 of the juvenile stages, 14 of the larval stages and 12 of the egg stages. Two major data sources were used; the catch data from the NMFS bottom trawl surveys of the area covered by the Groundfish FMP, and information on habitat-species associations in the habitat use database.

The NMFS surveys were considered to provide the best source of data and were hence analyzed first. An exploratory data analysis was undertaken to determine the best approach, using sablefish as a test case. The final model approach was then used to model the probability profiles for as many of the 82 species in the dataset that there were appropriate amount of data available for. The preliminary analysis concluded that a generalized linear model (GLM) or a generalized additive model (GAM) modeling continuous CPUE data was not suitable due to the vast amount of zero values, which violated the model assumptions. Better results werrre obtained by rearranging the data for the response variable as a binary variable (0 = no Sable fish in haul and 1 = Sable fish in haul), and modelling the response as a probability using a binary GLM or a binary GAM. The two prediction plots are provided in the analysis, one for the GLM and one for the GAM, showing similar patterns. The binary GAM was selected as the preferred method at this stage due to concerns that the output of the GLM showed too high a level of smoothing of the data.

Following discussion with the Council's SSC, it was noted that GAMs and GLMs that can accommodate zero catches have been commonly used to obtain indices of abundance using West Coast trawl survey data for stock assessment. There are limitations in using presence/absence information to infer the locations of EFH habit. For example, a species may have a broad depth or geographic distribution, but may only reach high densities in a limited area. The project team agreed, but had previously concluded that the use of presence-absence from a large number of surveys would provide the most robust result at this stage. While noting also that the analysis of depth and latitude ranges is only part of the input into the EFH model, EFH designations resulting from this analysis can be considered to be initial approximations that will need to be refined as additional information becomes available and more sophisticated analyses become possible.

This document contains some of the initial exploratory data analysis as well as three of the 18 profiles for adult fish that were completed entirely from the NMFS trawl survey data. An additional 16 species were completed using expert advice on the 0-30 meters depth interval that the NMFS surveys do not cover.

A total of 38 species (adults) were modeled using the NMFS survey data. The information on species-habitat associations in the Habitat Use Database (HUD) was used to calculate index profiles for as many more species and life stages as possible. This was achieved for a further 118 species-life stage combinations. Due to the nature of the data, these profiles contained much less information that those generated from the survey data. However they do represent the best information currently available from which to develop estimates of overall habitat suitability probability (i.e. including substrate preferences) using the EFH model.

2 EXPLORATORY DATA ANALYSIS

The following is a statistical analysis for the West Coast survey data for sablefish received from Waldo Wakefield (NMFS NW Fisheries Science Center).

This document tries to establish a relationship between CPUE data and two independent variables and three factors: Depth in meters, Latitude in decimal degree, interaction between these two, survey (factor), year (factor) and month (factor). The statistical analysis and the plots presented in this document were carried out in S-PLUS. Some observations considered outliers (errors) were removed from the data set. See section 4.2 for details.

The standard method for analyzing the survey data is NOT to treat each tow as coming from a unique "box" that has a unique area. Rather, the surveys were planned and analyzed as a pseudo-stratified random design. That is, large spatial strata defined by latitude and depth were laid out and the CPUE from all tows within a stratum is averaged and treated as the mean CPUE for that entire stratum. In the early years of the shelf survey (AK1) there were frequent shifts in stratum boundaries and shifts in the allocation of sampling effort between strata (especially in 1986). For the slope surveys and for the latter years (1992-2001) of the shelf survey, the allocation of effort is more nearly uniform which provides more flexibility for post-hoc analyses. The quality on the temperature data has not been critically evaluated. It is possible that some differences exist between the sensors used on the various surveys (Richard Methot).

The efforts (net width in meters * distance sampled in meters) for the surveys AK1, AK2 and NW are plotted in Figure 1. Due to the longer tow time for the two AK-surveys (30 minutes and 60 minutes) compared to the tow time the trawl for the NW-survey (15 minutes), the area covered by the surveys differs substantially. This difference in tow duration shows up as a bimodal distribution in Figure 1. The AK-surveys approximately cover double the area of the NW-survey for each haul.

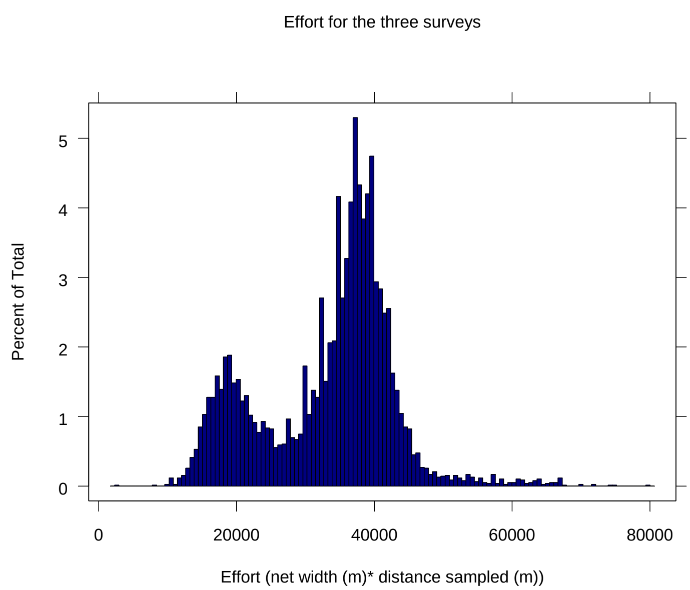

Figure 1: Histogram of the effort data used for sabelfish showing a shift in the mean for the surveys, indicating that systematical differences in tow duration for the surveys are present.

To achieve a standardize Catch Per Unit Effort (CPUE) index and eliminate the tow duration effect, the catch is divided by swept area in m^2. Due to the fact that the number of fish in each haul were generated from the catches in the earlier years, the catch data is preferred over the number data as a response variable.

$$CPUE = \left(\frac{\text{Catch (kg)}}{(\text{Distance sampled (m)} \cdot \text{Netwidth (m)})} \right) \qquad \textbf{(1)}$$

To explore the data, the two independent variables Depth and Latitude are plotted versus the CPUE. The resulting scatter plot of Depth and Latitude versus CPUE are plotted in Figure 2. From these plots it is clear that the CPUE scale must be transformed due to the exponential difference in CPUE between points which will stabilize the variance too. To achieve this, equation (1) is transformed into:

$$CPUE_{\log} = \log\left(\frac{\text{Catch (kg)}}{(\text{Distance sampled (m)} \cdot \text{Netwidth (m)})} \right) \qquad \textbf{(2)}$$

The two plots in Figure 3 do not reveal any clear linear relationship between $CPUE_{\log}$ and any of the 2 variables. Thus, suggesting non-linear relationships which will be tested in the proceeding using analysis of variance. Note that the observations at $CPUE_{\log} = 16$ are the zero values transformed this issue will be discussed in detail in section 3.

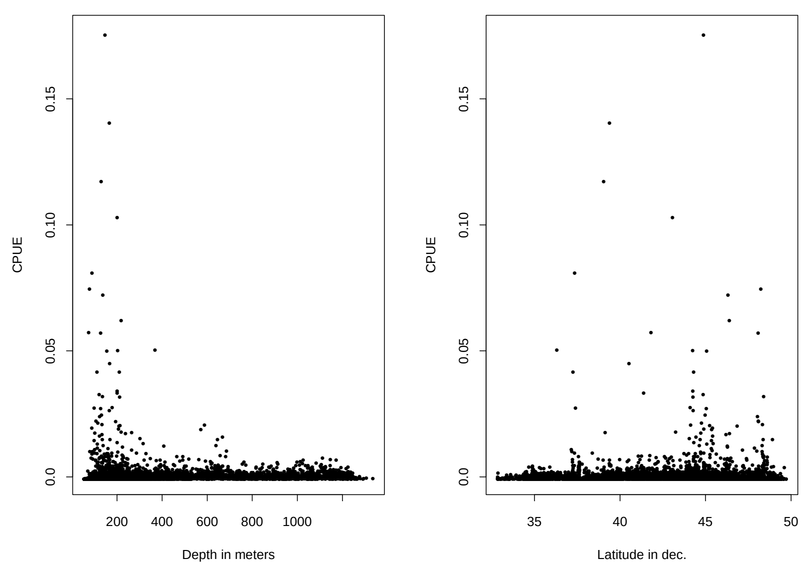

Figure 2: Scatter plots of Depth and Latitude versus CPUE.

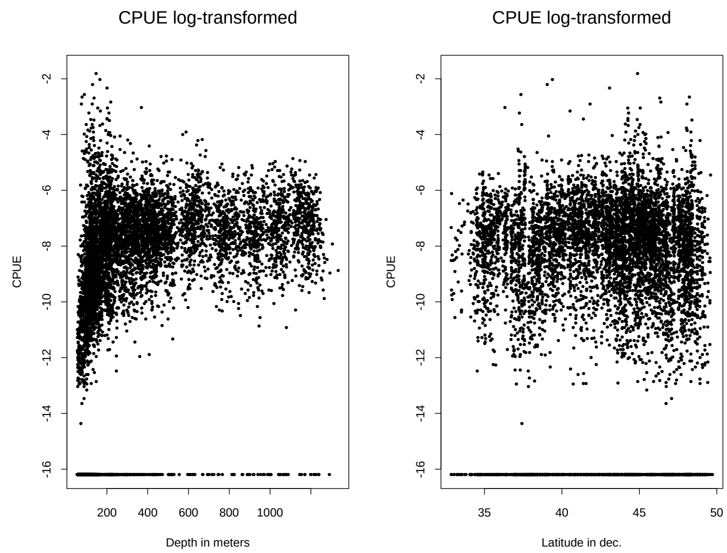

Figure 3: Scatter plots of Depth and Latitude versus log-transformed $CPUE_{\log}$.

It would be desirable to separate juveniles and adults in the data sets to test if there is a depth effect present (i.e. juveniles and adults are captured on different depths). For each haul, the count of sabelfish was dividing by the total weight and plotted in Figure 4. If the sabelfish data could be aggregated into adults and juveniles it would show up as a bimodal distribution in the plots however, which is not the case. Thus, the sable fish data can not be aggregated into juvenile and adult fish from the information given in these three data sets. To accomplish that task, the Age Length Key (ALK) and the length frequency data that is currently not available would have to be incorporated into the analysis. Due to the lack of ALK and ALD data, sable fish will be considered as one homogeneous population going forward.

There is a significant difference in the way the three surveys have been conducted through time. The two AK-surveys cover a much larger area than the NW-survey and include different designs that have a longer history as well. For these reasons, the analysis for the Sable fish will be carried out as a factor analysis where survey, year and month will be included as factors in the models.

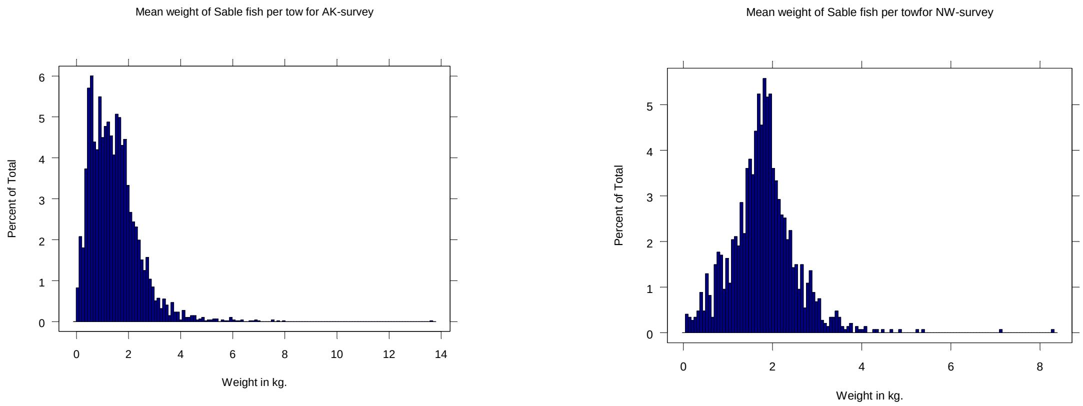

Figure 4: Histograms showing the mean weight of Sable fish in kg. per haul for the two AK-survey and the NW-survey respectively.

To explore if a non-linear relationship is present the two independent variables are plotted against their fitted values using cubic smoothing spline with 4 degrees of freedom and a loess smoother with span = 0.75. The results are presented in Figure 5.

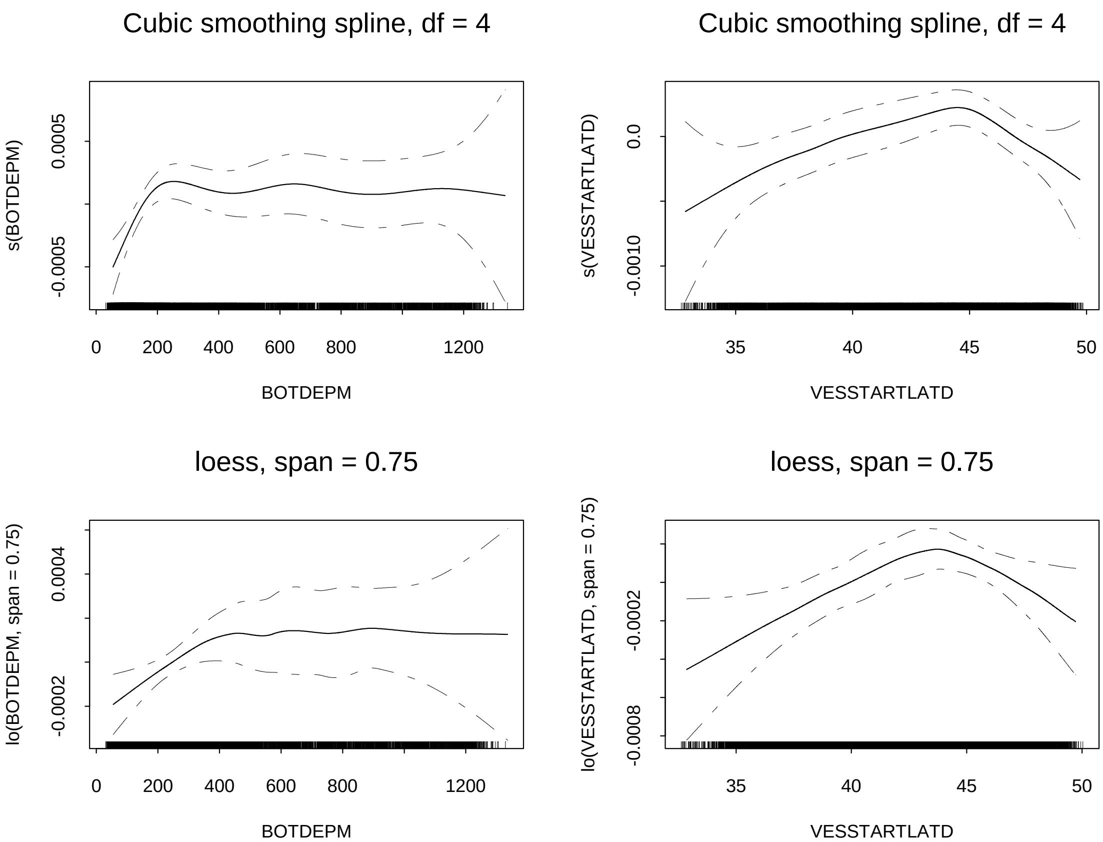

Figure 5: The result of fitting an additive model with smooth functions (cubic spline and loess) of the two predictors. The dashed lines are approximate 95% pointwise confidence intervals. The tick marks in the bottom of each plot show the location of the observation on that variable.

The general shape of the fits, produced by local regression and smoothing splines, (Figure 5) are quite similar and fits the data well. From these plots it is obvious that there is no linear relationship between log (CPUE) and depth and latitude respectively.

Because loess gives no weight to observations outside the set of nearest-neighbors in forming a local estimate of $E(y)$, it is more robust against outlying values on X than smoothing splines (Cleveland 1979). The NW, AK1 and AK2 data sets do have many extreme (outlying) values. Hence, the loess smoother should be preferred for analysis of these data sets.

The difference in the way local regression and cubic smoothing splines operate is generally overwhelmed by choices as to how much smoothing to do with a given brand of smoother. (i.e. “within smoother” variation seems to dominate “across smoother” variation). One caveat is that local regression generalizes to higher-dimensional settings more readily than spline functions. See Annex 1 for a description and comparison of GAM and choices of smoothers.

3 MODEL TESTING (SELECTION)

Modeling continuous CPUE for sable fish can be done in many different ways, e.g. using a generalized additive model or a generalized linear model. In this section, two different model approaches will be undertaken; firstly a generalized additive model (GAM) modeling the continuous $CPUE_{\log}$ data derived in equation (2) will be presented. Thereafter a generalized linear model (GLM) with binary response will be derived and finally a GAM with binary response will be derived at the end of this section.

3.1 Generalized Additive Model, continuous response

To test if a linear model (LM) is appropriate for modeling $CPUE_{\log}$ the depth as an independent variable is tested for linearity by an analysis of variance; i.e. a LM is tested against a GAM model and the independent variable latitude is tested for linearity in the same manner.

$$Model1: E(CPUE_{\log}) = S + Y + M + Depth \tag{3}$$

and

$$Model2: E(CPUE_{\log}) = S + Y + M + loess(Depth) \tag{4}$$

Where S is a factor representing survey (4 levels), Y is a factor for year (1997,…,2002) M is a factor for month (6, 7, …, 11).

These two models are tested up against each other for each survey and the results of the analysis of variance (ANOVA) are presented in Table 1.

The hypothesis that there is a linear relationship between $CPUE_{\log}$ and Depth data is tested

Table 1: ANOVA table for Model1 in equation (3) tested against model2 in equation (4).

Terms	Resid. DF	RSS	Test	DF	Sum of Sq	F value	Pr(F)
Depth	7756.000	0.1322277					
Loess(Depth)	7754.733	0.1321402	1 vs. 2	1.267218	0.00008752	4.053259	0.034520

The reduction of RSS from 0.1322277 (the linear fit) to 0.1321402 Table 1 is statistical significant ($\alpha = 0.05$) with an extra 1.267218 degrees of freedom. The hypothesis that there is a linear relationship between $CPUE_{\log}$ and Depth data for the surveys is discarded.

Next, the hypothesis that there is a linear relation ship between $CPUE_{\log}$ and Latitude for the survey data is tested. The two models in equation (5) and equation (6) are tested up against each other and the results of the ANOVA are presented in table Table 2.

$$Model2 : E(CPUE_{\log}) = S + Y + M + Latitude \tag{5}$$

and

$$Model2 : E(CPUE_{\log}) = S + Y + M + loess(Latitude) \tag{6}$$

Where S is a factor representing survey (4 levels), Y is a factor for year (1997,…,2002) M is a factor for month (6, 7, …, 11).

The hypothesis that there is a linear relationship between $CPUE_{\log}$ and Latitude data for the surveys is tested

Table 2: ANOVA table for Model3 in equation **(5)** tested against model4 in equation **(6)** for the survey data.

Terms	Resid. DF	RSS	Test	DF	Sum of Sq	F value	Pr(F)
Latitude	7756.00	0.1322593					
Loess(Latitude)	7754.77	0.1320621	3 vs. 4	1.230136	0.0001972	9.4126	0.0010156

The reduction of RSS from 0.1322593 (the linear fit) to 0.1320621in Table 2 is statistical significant ($\alpha = 0.05$) with an extra 1.230136 degrees of freedom.

The hypothesis that there is a linear relationship between $CPUE_{\log}$ and Latitude data for the surveys is discarded.

These two ANOVA tests confirm what could be seen in the plots in Figure 5 that the relationships between $CPUE_{\log}$ and depth; $CPUE_{\log}$ and latitude indeed are non-linear.

The next step is to include depth, latitude and the interaction between depth and latitude and, the three-factors survey, year and month in a generalized additive model, and finally test if all the terms are significant. The full, generalized additive model is shown in equation (7).

$$E(CPUE_{\log}) = S + Y + M + loess(Latitude) + loess(Depth) + loess(Latitude, Depth) \quad \textbf{(7)}$$

Where S is a factor representing survey (4 levels), Y is a factor for year (1997,…,2002) M is a factor for month (6, 7, …, 11) .

Then an ANOVA is carried out to see if any terms can be eliminated and the result is presented in Table 3.

Table 3: ANOVA table for model 5 in equation **(7**) for the AK-survey data, added 1e-7 to all CPUE observation before log-transformation.

Terms	DF	Npar DF	Npar F	Pr(F)
Intercept	1			
MONTH	5			
SURVEY	2			
YEAR	16			
Lo(BOTDEPM)	1	1.3	542.5211	0.000000e+000
Lo(VESSTARTLATD)	1	1.2	28.6917	5.037583e-009
Lo(VESSTARTLATD, BOTDEPM)	0	3.3	180.2557	0.000000e+000

All the terms in the ANOVA table (4) are significant and cannot be removed from the model. Thus, the full model is the final one.

To see if the model violates the assumption about normal distributed errors, we look at the residuals in Figure 6 and Figure 7. It is obvious from these two figures that the choice of number added to CPUE before log transforming it $(\log(0) = -\infty)$ is very important. The reason for adding a number to all CPUE observations is to shift the axis slightly since it is not possible to take the logarithm to zero. It would be obvious to add 1 to all CPUE observations before log-transforming it since log(1)=0, but as shown in Figure 7 that would violate the assumption of normal distributed errors. The reason why *1* will not work with this data set is due to the relative small values for CPUE. The largest value for CPUE is 0.176. The decision to choose the number 1e-7 as the constant added to all CPUE observations was made by substantially testing different numbers. The number 1e-7, that is one-fifth the smallest CPUE, came out with the best looking residual plots. (Note: the line with a negative slope in the first residual plot is the residuals of the transformed zeros plotted against their fitted values) This shape occurs because the model is treating these values as constants over the fitted interval with increasing residuals. From the third plot, there is a large number of values with very high leverage (the values to the right of the vertical line in the plot). These values (the extreme catches) have very high influence on the fit and there by on the coefficients of the model and it would be advisable to exclude the 26 observations with hatvalues > 0.015. The fourth plot shows that the model fits the CPUE observations reasonably well.

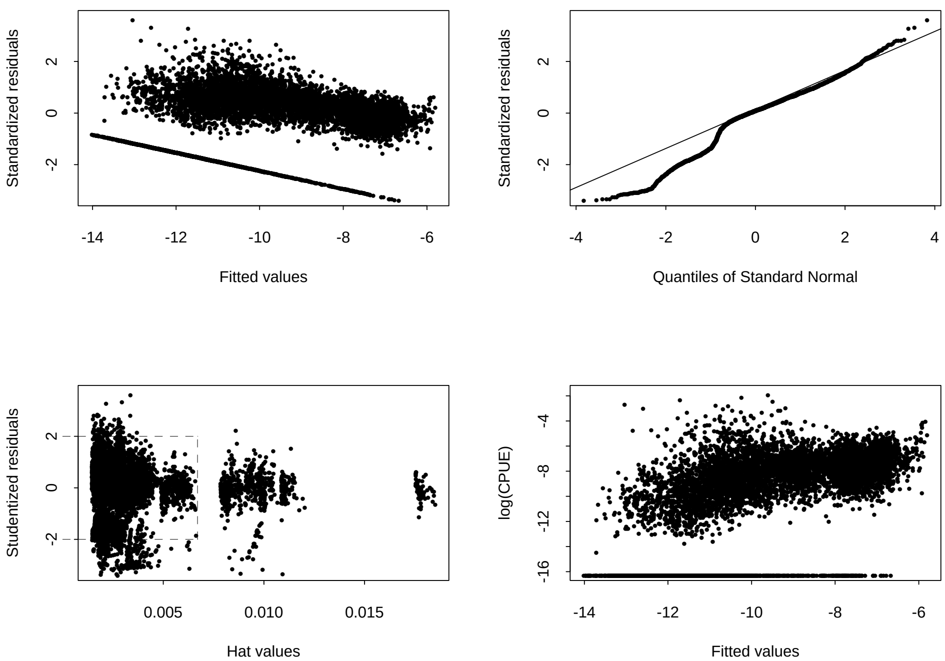

Figure 6: Residual plot for the final model in equation **(7)**, added 1e-7 to all CPUE observation before log-transformation.

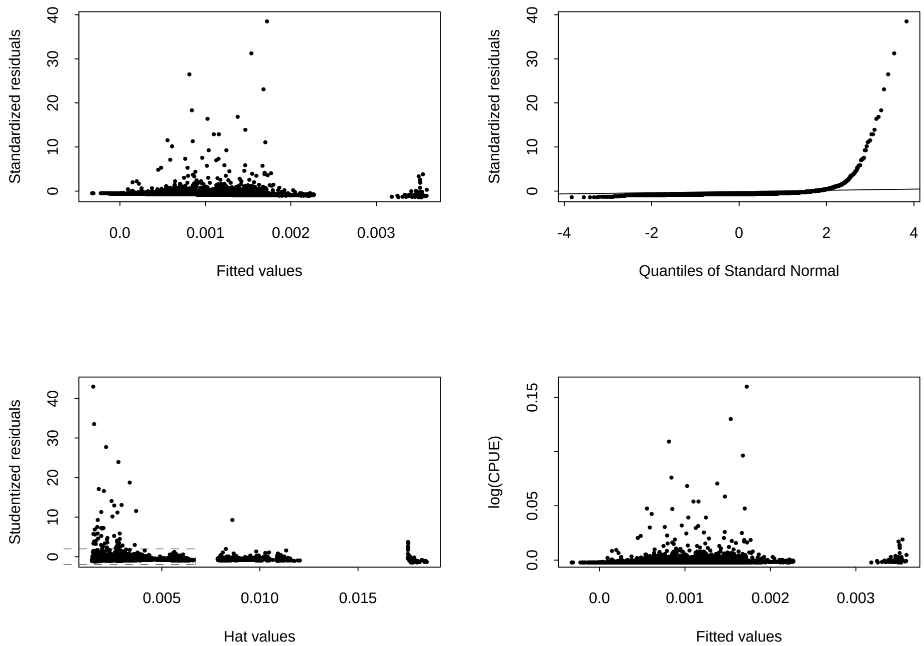

Figure 7: Residual plots for the final model in equation **(7)**, added 1 to all CPUE observation before log-transformation.

Figure 8 shows a prediction for year 2002, survey 3(NW-survey) and July month using the fitted generalized additive model from equation (7). (Note: the spike in the probability for low depth between latitude 42 and 46.) This phenomena is due to some few extreme hauls that influence the model very much and these values should be considered removed from the dataset, if the more general pattern is to be explored in full depth.

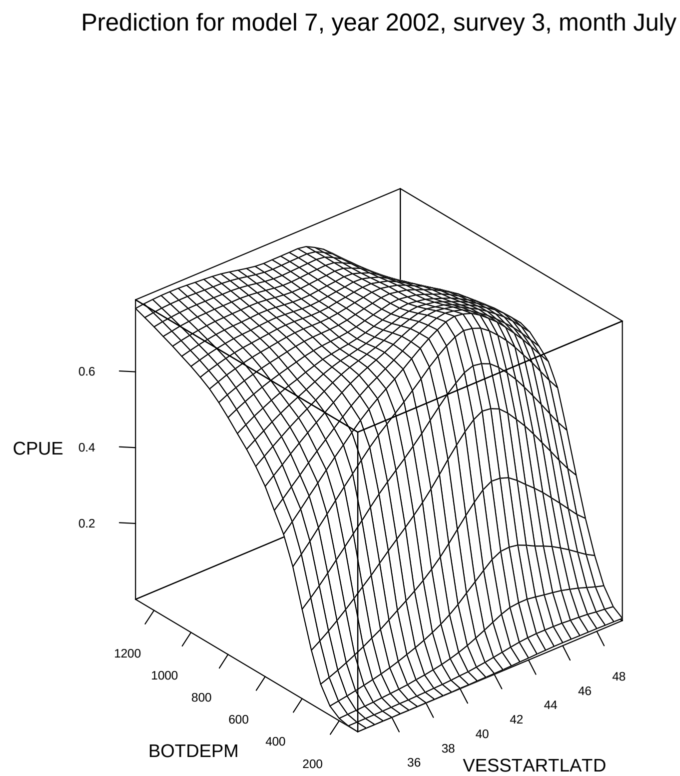

Figure 8: Prediction example for model 7, for year 2002, survey 3 (NW-survey) and month July.

To summarize these results so fare, a GAM modeling CPUE for the NMFS survey data violates the distributional assumptions and should therefore not be used.

3.2 Generalized Linear Model, binary response

Due to the many extreme values (catches over 1200 kg) and due to the large number of zero catch observations >1500, a more robust and simple model would be preferable.
A model that would not be sensitive to these extreme observations would be a generalized linear model where CPUE was modeled as a binary variable (0 if no Sable fish are present in haul, 1 if Sable fish are present in haul).

$$CPUE = \begin{cases} 0; \text{no Sable fish are present in haul} \\ 1; \text{Sable fish are present in haul} \end{cases}$$

To illustrate this point, present/non-present as a binary response variable was modeled using a GLM[1] with a logit link function. Let $p = (\,prob(CPUE > 0)$

First the full model in including all possible terms is modeled

$$E[\log it(p)] = S + Y + M + Latitude + Depth + Latitude : Depth \qquad \textbf{(8)}$$

Where S is a factor representing survey (4 levels), Y is a factor for year (1997,…,2002) M is a factor for month (6, 7, …, 11) and $\log it(p) = \log(p/(1-p))$.
Fitting the GLM in equation (8) and performing analysis of deviance (see Table 4) with the "step" function in S-plus, gives the following model reduction (see equation (9)).

Table 4: Analysis of Deviance table for the generalized linear model in equation **(8)**.

STEP	Df	Deviance	Resid. Df	Resid. Dev	AIC
			7731	6124.409	6178.409
- MONTH	4	4.738981	7735	6129.148	6175.148
- BOTDEPM:VESSTARTLATD	1	1.319705	7736	6130.468	6174.468

$$E[\log it(p)] = S + Y + Latitude + Depth \qquad \textbf{(9)}$$

Where S is a factor representing survey (4 levels), Y is a factor for year (1997,…,2002) and $\log it(p) = \log(p/(1-p))$.

[1] A good reference to an in-depth discussion of GLM's would be (McCullagh and Nelder 1989).

Fitting this model yields the following coefficients:

Table 5: Coefficient values, standard errors and t values for the reduced model in equation **(9)**.

Coefficients			
	Value	Std. Error	t value
Intercept	-1.509150737	0.4800761093	-3.1435656
YEAR1	-0.145852595	0.0776847019	-1.8774944
YEAR2	0.056511997	0.0414481813	1.3634373
YEAR3	0.138727608	0.0313849930	4.4201892
YEAR4	0.830857084	0.8705720706	0.9543806
YEAR5	-0.106693791	0.1462337091	-0.7296115
YEAR6	0.468632587	0.4645555060	1.0087763
YEAR7	-0.080407854	0.1618935525	-0.4966711
YEAR8	-0.117183713	0.0778290599	-1.5056550
YEAR9	-0.079984538	0.0968315204	-0.8260176
YEAR10	-0.072746081	0.0522472365	-1.3923431
YEAR11	0.267120360	0.1937121769	1.3789549
YEAR12	-0.124748025	0.0525882620	-2.3721648
YEAR13	-0.116078047	0.0349055916	-3.3254857
YEAR14	-0.050600105	0.0324421283	-1.5597036
YEAR15	-0.019917502	0.0292700936	-0.6804728
YEAR16	-0.023831303	0.0236303142	-1.0085055
YEAR17	-0.028614817	0.0233262161	-1.2267235
SURV1	0.511277683	0.1609899263	3.1758365
SURV2	-0.419443130	0.0613042600	-6.8419899
BOTDEPM	0.006373999	0.0003268699	19.5001112
VESSTARTLATD	0.051565244	0.0076938270	6.7021580
Null Deviance	7656.014	Df	7757
Residual Deviance	6130.468	Df	7736

Since the responses are binary, even if the model is correct, there is no guarantee that the deviance will have even an approximately chi-squared distribution, but since the deviance value is about in line with its degrees of freedom, there is no reason to question the fit. Residuals are not very informative with binary responses. A better measure is to check if the deviance is in line with the degrees of freedom.

An example of probability plotted versus latitude and depth for year 2002 and survey 3 (NW-survey) is given in Figure 9. This plot is very similar to the prediction plot for the generalized additive model in Figure 8. The binary GLM prediction average over multiple months, while the GAM prediction is shown for July only. The GLM fits very well, keeping in mind that it is a much simpler model compared to the GAM fitted on log(CPUE) response.

To summarize the results thus far, would be to suggest the use of the GLM due to simplicity and that the fitted values are directly interpretable as probabilities.

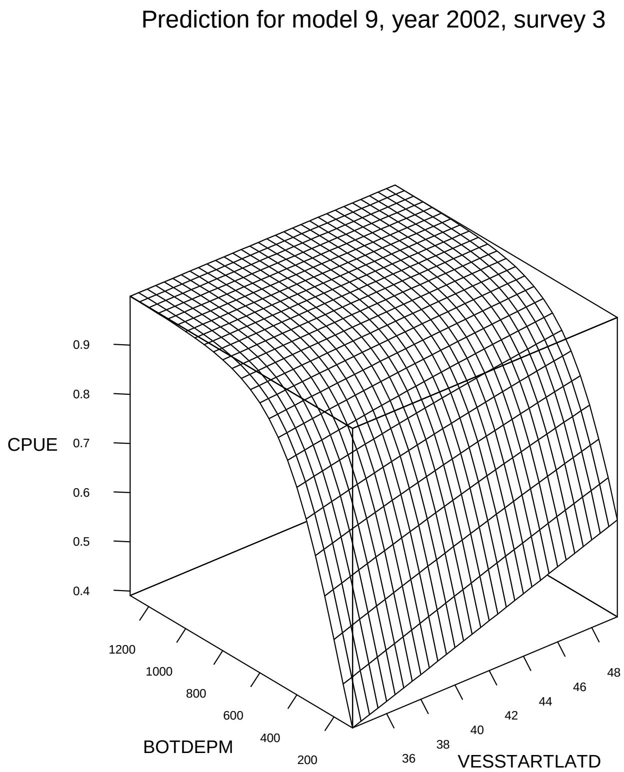

Figure 9: Prediction example for model 9, for year 2002, survey 3 (NW-survey).

3.3 Generalized Additive Model, binary response

Another model that would not be sensitive to these extreme observations would be a generalized additive model where CPUE was modeled as a binary variable P (0 if no sable fish are present in haul, 1 if sable fish are present in haul).

$$CPUE = \begin{cases} 0; \text{no Sable fish are present in haul} \\ 1; \text{Sable fish are present in haul} \end{cases}$$

To illustrate this point, present/non-present as a binary response variable was modeled using a GLM[2] with a logit link function. Let $p = (\, prob(CPUE > 0)$

At this point it was decided to eliminate year, month and survey as factors in the analysis, since they would not be used for prediction in the final model.

[2] A good reference to an in-depth discussion of GLM's would be (McCullagh and Nelder 1989).

Fitting the full GAM in and performing analysis of variance with the “step” function in S-plus, produces the following model reduction:

$$E[\log it(p_i)] = \beta_0 + \sum_{j=1}^{2} f_j(x_{ij}) \qquad \textbf{(10)}$$

Where, $\log it(p) = \log(p/(1-p)), i = 1,\ldots,8185$ and $x_{i1} = latitude_i$ and $x_{12} = depth_i$.

In Figure 10 a prediction using the fitted model in equation (10) for sable fish is shown, the GAM uses 6 degrees of freedom for the two cubic smoothers.

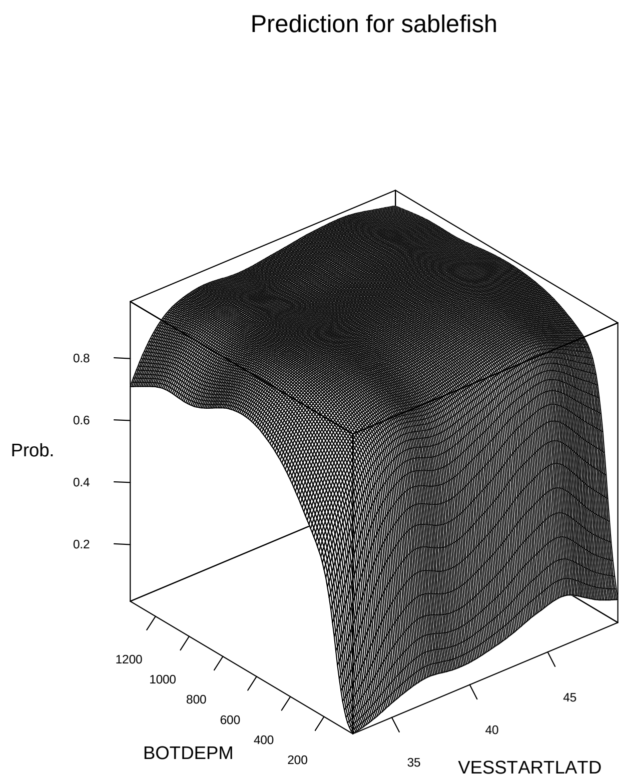

Figure 10: Prediction example for model 10, for all years.

From this preliminary data analysis it was decided that this GAM approach would be used instead of the similar GLM approach due to the higher level of smoothness induced by the GLM approach, see Figure 9. It was also decided that a cubic smoother with 6 degrees of freedom smoothed the data most accordingly.

4 COMPLETED GAM MODELS

4.1 Technical decision rules

As described in the previous section, a GAM with 6 degrees of freedom was considered to smooth the data most appropriately and the GAM in equation (11) was applied to all the available species in the NMFS surveys. In the following subsections of this section, the analysis of the 18 species that the NMFS survey data covered completely, will be given.

In the following sections technical measures for goodness of fit for each of the species in the FMP will be provided. In these sections, it will be documented which model approach, if any, was used. Further, in each section a plot of the complete Habitat Suitability Probability profile (HSP) that was used in the HSI model is given for each species. A goodness of fit estimate will be given in the following format:

	False	True
0	7368	76
1	585	156

The incorrect predictions are the off-diagonal entries where the model predicts true when the data is 0 and when the model predicts false when the data is 1. In the example above the prediction error rate was 8.1% and this table will be used as a goodness of fit measure in the following sections.

When there are sufficient data available, the following GAM will be fitted for each species in the following sections.

$$E[\log it(p_i)] = \beta_0 + \sum_{j=1}^{2} f_j(x_{ij}) \qquad \textbf{(11)}$$

Where, $\log it(p) = \log(p/(1-p)), i = 1,...,8185$ and $x_{i1} = latitude_i$ and $x_{12} = depth_i$.

A measure of over-dispersion will also be provided for each species that was modeled using the GAM in equation (11). This measure will be significantly greater (>>) than 1 if over-dispersion is present. This means that if the dispersion is >>1 the data will be modeled using the GAM in equation (11) with a Quasi-likelihood family with logit link. When the dispersion is not substantially larger than 1 the GAM in equation (11) will be modeled with a binomial family and logit link.

4.2 Outliers

There were three records in the NW-surveys file with gear temperature equal to zero which have been removed. In the same file there were 7 observations where duration in hours was equal or less than zero which have also been removed. Moreover, 26 records with extreme CPUE where identified but kept in the dataset. The sample I.D., for the 12 most extreme values, is shown below. Richard Methot confirmed their validity, therefore, keeping these values in the dataset.

geartempc=0, all in NW-surveys

```
  SAMPLEID
----------
199801002041
199801002068
199901006044
```

Records with duration <=0, only found in NW-surveys.

```
  SAMPLEID
----------
200101006081=0
200101006088=0
200101009003=0
200101009025=0
200101009036=0
200101009040=0
200001006011 = -11.45
```

Records with extreme CPUE. All in the AK-surveys file.

```
  SAMPLEID
----------
     39637
     39679
     40984
     43322
     43338
     43644
     45532
     46083
     46101
   1090097
   1090357
   1090366
```

4.3 Aurora rockfish

Aurora rockfish was present in 948 hauls out of the 8,185 hauls. The HSP was developed entirely from fitting the GAM to the NMFS survey data.

Table 6: Prediction error rate.

	False	True
0	7043	194
1	239	709

From Table 6, the prediction error rate is calculated to be 5.3%, suggesting a good fit to the data.

The dispersion parameter for the Quasi-likelihood family is 0.9469618, indicating no over-dispersion.

The HSP is shown in Figure 11.

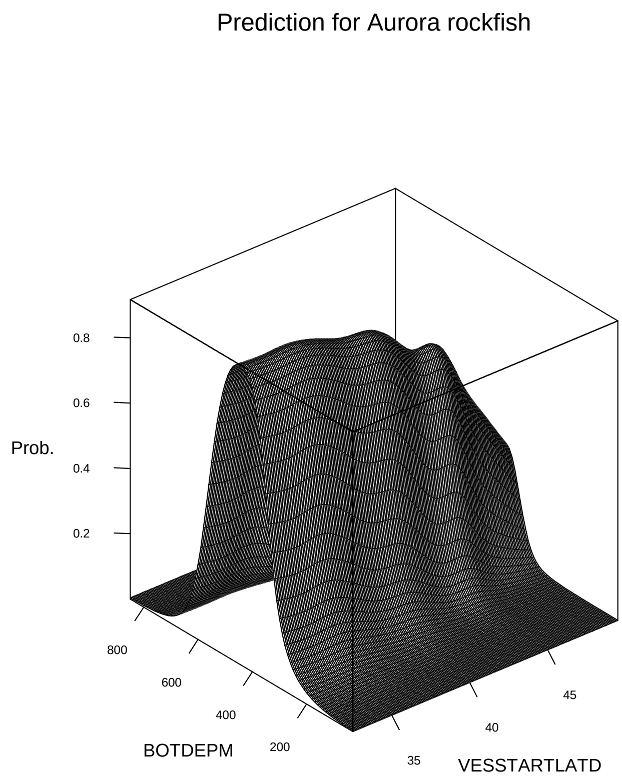

Figure 11: HSP for aurora rockfish.

4.4 Darkblotched rockfish

Darkblotched rockfish was present in 2,297 hauls out of the 8,185 hauls. The HSP was developed entirely from fitting the GAM to the NMFS survey data.

Table 7: Prediction error rate.

	False	True
0	5188	700
1	744	1553

From Table 7, the prediction error rate is calculated to be 17.6%, suggesting an average fit to the data.

The dispersion parameter for the Quasi-likelihood family is 0.9188649, indicating no over-dispersion.

The HSP is shown in Figure 12.

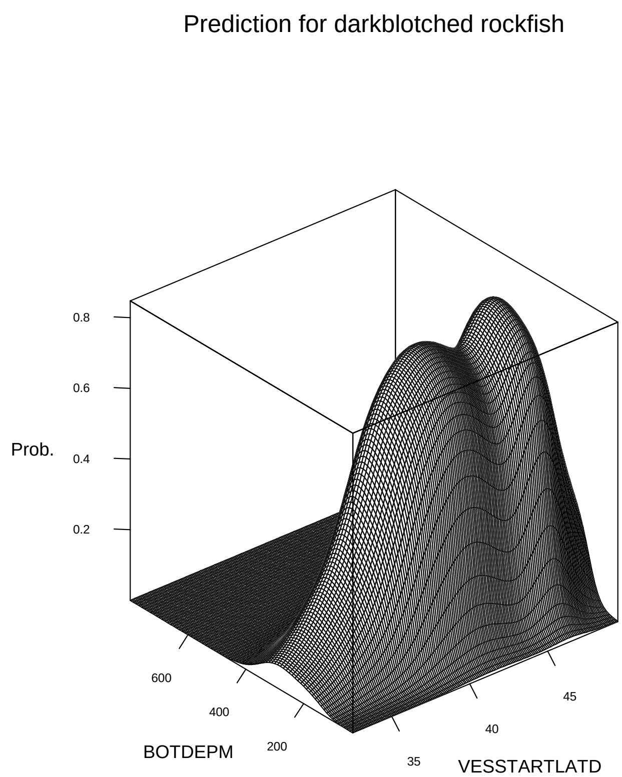

Figure 12: HSP for darkblotched rockfish.

4.5 Greenstriped rockfish

Greenstriped rockfish was present in 2,184 hauls out of the 8,185 hauls. The HSP was developed entirely from fitting the GAM to the NMFS survey data.

Table 8: Prediction error rate.

	False	True
0	5372	629
1	516	1668

From Table 8, the prediction error rate is calculated to be 14.0%, suggesting a good fit to the data.

The dispersion parameter for the Quasi-likelihood family is 1.000763, indicating no over-dispersion.

The HSP is shown in Figure 13.

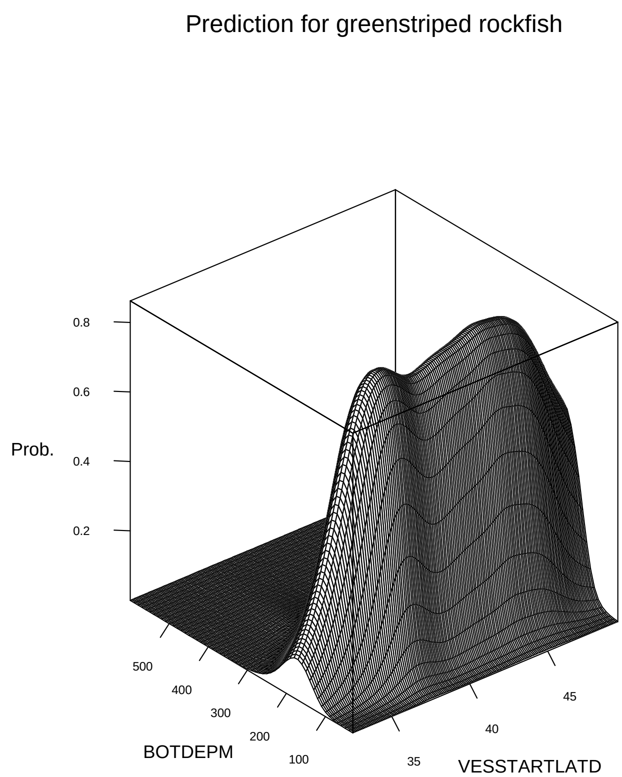

Figure 13: HSP for greenstriped rockfish.

5 SURVEY PROFILES COMPLETED USING EXPERT ADVICE

For 16 species the habitat suitability profiles created from the NMFS survey were almost complete only missing information in the 0-30 meters depth interval. Spread sheets for these species were developed and send out to expert on these specific species requesting them to complete the 0-50 meters depth interval, see Figure 14. The 40 and 30 meters column was then compared to the output from the model and the 20, 10 and 0 column were incorporated in the partially completed profile increasing the number of completed habitat suitability profiles for adults from 18 to 34.

Figure 14: Sample of spread sheets that was filled out by expert, grayed area filled out by expert.

	Depth in 10-m intervals								
Latitude (degrees)	**70**	**60**	**50**	**40**	**30**	**20**	**10**	**0**	
49	0.96023	0.97329	0.98212	0.98	0.98	0.7	0.3	0.1	Washington
48	0.95263	0.9681	0.97861	0.98	0.98	0.7	0.3	0.1	Washington
…	…	…	…	…	…	…	…	…	…
34	0.94459	0.96258	0.97486	0.75	0.5	0.2	0.1	0.1	So. Calif. Bight
32-33	0.75	0.75	0.5	0.5	0.2	0.2	0.1	0.1	So. Calif. Bight

6 THE HUD METHOD

It was only possible to produce 36 complete habitat suitability probability profiles from the NMFS trawl survey data (including those completed with additional expert opinion). All of these were assumed to be for adults only. Size composition data are available for many groundfish from the surveys and these could be used to distinguish juveniles from adults in the survey hauls, however, such a detailed analysis was outside the scope of the current study and the size composition data were not used.

In order to complete habitat suitability probability profiles for more species and life stages, a procedure was developed for using basic data on depth and latitude preferences from the HUD. Depth preferences are characterized in the HUD with four depths: minimum observed depth, minimum preferred depth, maximum preferred depth, and maximum observed depth (AbsMinDepth, PrefMinDepth, PrefMaxDepth, AbsMaxDepth repsectively). Geographic (latitude) preferences are recorded similarly (AbsMinLat, PrefMinLat, PrefMaxLat and

AbsMaxLat respectively). The preferred minimum and maximum depths (and latitudinal ranges) are roughly based on the 5th and 95th percentiles from surveys when these data are available. Not all of these data are available for all species and life stages. No data are recorded in the HUD for a total of 74 species/life stage combinations, 56 of which are eggs and 17 of which are larvae. A further 94 combinations (mainly larvae and juveniles) have so little data in the HUD that it is not possible to develop profiles. This leaves 124 combinations for which profiles could be developed from the HUD.

As described above, there are up to four different values recorded each for depth and latitude in the HUD. Assuming that the habitat will be most suitable for the species somewhere between the preferred minimum and preferred maximum depth and latitude an extra point, termed the "optimum" can be created for both depth and latitude. For simplicity, the discussion going forward will be narrowed down to discuss the depth observations since the same principle will be applied to the latitude observations.

Here we use Pacific Ocean perch (adults) to illustrate the approach, because it is a species for which we have both the survey data results and a full complement of data in the HUD (Table 9). The optimum value in Table 9 is calculated as

$$Optimum_{depth} = \frac{\text{PrefMinDepth} + \text{PrefMaxDepth}}{2}$$

i.e. the mean value between PrefMinDepth and PrefMaxDepth. An index value, which is a proxy for the habitat suitability probability calculated from the survey data in Section 4 is then assigned to each of the five depth points. This has the value of 0.0 at AbsMinDepth and AbsMaxDepth. The optimum is given the value of 1 (the maximum possible value). It then remains to assign index values for the PrefMinDepth and PrefMaxDepth. Following discussions with the SSC's Groundfish Sub-Committee, it was decided to calculate these values from the 36 profiles completed from the survey data. We have the actual habitat suitability probability values at the PrefMinDepth and PrefMaxDepth for these species. We took the averages of these values and used those for the HUD species. These values were 0.19 at PrefMinDepth and 0.236 at PrefMaxDepth.

Table 9: Observed values from the HUD and their assigned index values.

Pacific ocean perch Adults	Abs Min Depth	Pref Min Depth	Optimum	Pref Max Depth	Abs Max Depth
Value	25	100	275	450	825
Index value	0.0	0.19	1	0.236	0.0

The five points (depth, index) were then plotted in Figure 15 and four lines drawn between them (the Habitat line). Data were extracted from these four lines and fed to a GAM that smoothed the data (the Smooth line). The line "Survey" in Figure 15 is the profile produced from the survey data and was included in the plot to compare the HUD approach with the binary GAM approach used for the survey data.

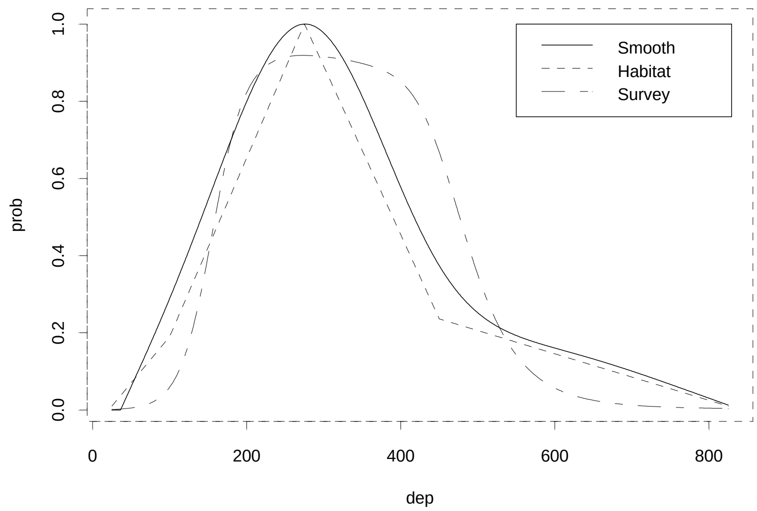

Figure 15: The HUD approach compared to the GAM (Survey) approach using Pacific Ocean perch as an example.

The depth profile in Figure 15 (Smooth) was then extrapolated over the latitude 32 to 49 and the result is shown in Figure 16.

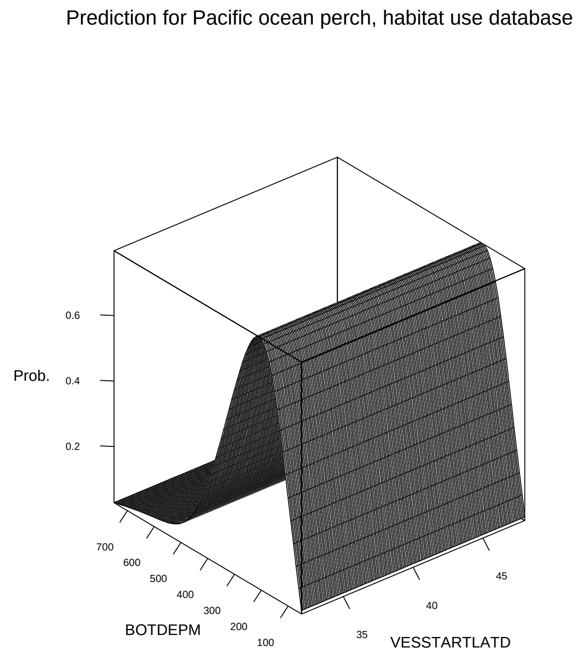

Figure 16: HUD depth profile extrapolated over the latitude interval 32-49 degrees.

The same procedure was then performed for the latitude data and the two profiles were multiplied together and scaled up so the maximum Index value yields 1.

$$HUD_{index} = Depth_{index} \cdot Latitude_{index}$$

We note that the values produced by this method are not strictly probabilities and are therefore not directly comparable with the habitat suitability probabilities derived from the survey data. They are index values that are scaled up to the maximum possible value of 1. The final index profile is shown in Figure 17.

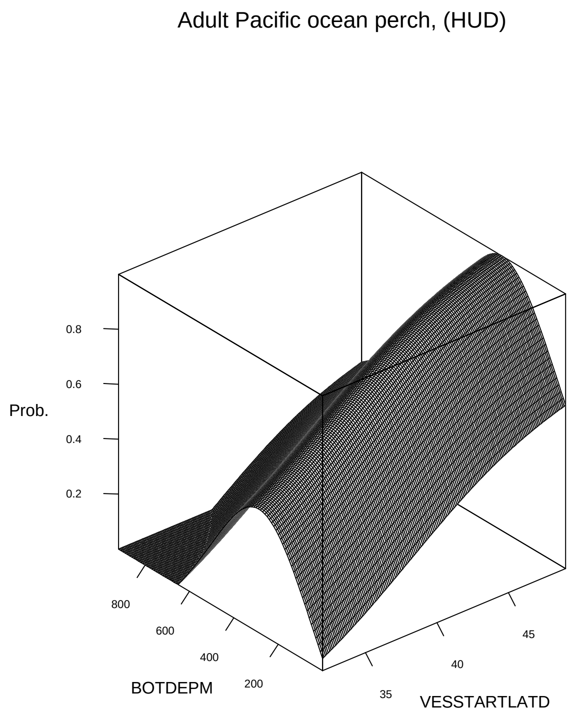

Figure 17: Index profile for adult pacific ocean perch, based on the observations in the HUD.

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ANNEX 1: A PRIMER ON GENERALIZED ADDITIVE MODELS

Additive models recast the linear regression model

$$y_i = \alpha + \sum_{j=1}^{k} \beta_j X_{i,j} + \varepsilon_i \quad \textbf{(12)}$$

by modeling y as an adaptive combination of arbitrary univariate functions of the independent variables and a zero mean, independent and identically distributed stochastic disturbance:

$$y_i = \alpha + \sum_{j=1}^{k} g_j(X_{i,j}) + \varepsilon_i \quad \textbf{(13)}$$

where $E(\varepsilon_i) = 0$ and $\operatorname{var}(\varepsilon_i) = \sigma^2, i = 1,...,n.$ No distributional assumptions about the ε_i are necessary before inference (hypothesis testing, constructing confidence intervals, etc). Generalized additive models extend the framework in equation (13) in precisely the same way that generalized linear models (GLMs) (McCullagh and Nelder 1989) extend the linear regression model in equation (12) so as to accommodate qualitative dependent variables.

Interpreting GAMs

The absence of the regression parameter β_j in equation (13) reflects an important characteristic of GAMs. One does not obtain a set of regression parameters from a GAM, but rather, estimates of $g_j(X_{i,j})$ for every value of $X_{i,j}$ denoted as $\hat{g}_j(X_{i,j})$ that tells us about the relationship between X_j and the dependent variable. It is possible to extend equation (13) to accommodate for linear terms too, called a semi-parametric model:

$$y_i = \alpha + \sum_{l=1}^{m} \beta_l Z_{i,l} + \sum_{j=1}^{k} g_j(X_{i,j}) + \varepsilon_i \quad \textbf{(14)}$$

The actual values of $\hat{g}_j(X_j)$ are not substantively meaningful *per se*: Important, is the shape of the fitted functions.
For this reason, graphical methods are used to interpret the non-parametric component of a GAM. A plot of X_j versus $\hat{g}_j(X_j)$ reveals the nature of any estimated non-linearity in the relationship between X_j and the dependent variable — holding constant the other components in the model. Standard errors and confidence regions can be calculated and plotted about $\hat{g}_j(X_j)$, providing a guide as to whether the fitted function is distinguishable from a linear fit, or increasing or decreasing in X_j.
While it may seam easier to examine tables of regression coefficients rather than scatter plots, this ease is only obtained at the cost of unwarranted, restrictive and unnecessary assumptions of linearity.

Scatterplot smoothing

The statistical theory for GAMs is complex; however, most of the key intuitions about GAMs flow from ideas having to do with bivariate, scatterplot smoothing.

Smoothing is an important tool for non-parametric regression, addressing one of the simplest, yet most fundamental questions in data analysis: "what is our best guess of y, given x?"
To define scatterplot smoothing, let $\mathbf{x}(x_1,...,x_n)'$ stand for the observations of an independent variable and let $\mathbf{y} = (y_1,...,y_n)'$ stand for the observations on a dependent variable. Assume that the data is sorted by **x**. A scatterplot smoother takes **x** and **y** and returns $\hat{g}(X) = \hat{y}$ also called the kernel, the kernel values sums to one. (i.e. may be negative at times).

Smoothing by local regression (loess)

Given a target point x_0

1. Identify the k nearest neighbors of x_0, i.e., the k elements of **x** closest to x_0. This set is denoted $N(x_0)$. In Splus k is controlled via a "span" argument which defines the size of the neighborhood.
2. Calculate $\Delta(x_0) = \max_{N(x_0)} |x_0 - x_i|$ the distance of the near-neighbor most distance from x_0.
3. Calculate weights w_i for each point in $N(x_0)$, using the following tri-cube weight function $W\left(\frac{|x_0 - x_i|}{\Delta(x_0)}\right)$
4. Regress **y** on **x** and a constant (for local linear fitting), using weighted least squares (WLS) with weights w_i as defined above.
5. The smoothed value $\hat{g}(x_0)$ is the predicted value from the WLS fit at x_0.

Local regression can also be applied beyond the two-dimensional setting encountered in scatterplot smoothing.

Cubic smoothing splines

Cubic smoothing splines are another popular choice for scatterplot smoothing and fitting GAMs. This smoother arises as the solution to the following optimization problem: among all functions $g(x)$ with continuous first and second order derivatives, find one that minimizes the penalized residual sum of squares

$$PRSS = \sum_{i=1}^{N} \left[y_i - g(x_i) \right]^2 + \lambda \int_a^b \left[g''(t) \right]^2 dt, \qquad \textbf{(15)}$$

Where λ is a fixed constant, and $a \leq x_1 \leq ... \leq x_N \leq b$ (Hastie and Tibshirani 1990, 27).
In equation (15) λ is analogous to the span parameter in loess, i.e., higher values of λ result in smoother fits.

Appendix 19

Evaluation of a US West Coast Groundfish Habitat Conservation Regulation via Analysis of Spatial and Temporal Patterns of Trawl Fishing Effort

Evaluation of a US West Coast Groundfish Habitat Conservation Regulation via Analysis of Spatial and Temporal Patterns of Trawl Fishing Effort.

Marlene A. Bellman and Scott A. Heppell
Department of Fisheries and Wildlife
Oregon State University
104 Nash Hall
Corvallis, Oregon 97331
marlene.bellman@oregonstate.edu
scott.heppell@oregonstate.edu

ABSTRACT

Recent emphasis on linkages between essential fish habitat and fish stock productivity has raised concerns about the management of fishing activities such as trawling, which have the potential to impact fish habitat. Knowing specifically where and how intensively trawl effort has occurred over time provides ecologists with the necessary background for habitat impact and recovery studies, and provides fishery managers with an assessment of how habitat conservation objectives are being met. The objectives of this study were (1) to examine the extent to which the 2000 Pacific Fishery Management Council footrope restriction has shifted and reduced trawl fishing effort on Oregon fishing grounds, (2) to relate these changes in distribution to the benthic habitat type over which they occur, and (3) to develop methods for enhancing fine-scale spatial review of targeted fishing effort.

Density analysis of available trawl start locations provided a spatial and temporal understanding of how fishing efforts increased and decreased in relation to habitat distribution and fishery management actions between 1995 and 2002. Trawl effort patterns exhibit significant inter-annual variability and patchy distribution. Areas of increased fishing effort were still evident between years despite an overall decline in trawl tows across the time scale of this study. Tow end point locations for the years 1998-2001 were retrieved from manual logbooks for five reference sites located in the proximity of rock habitat features. Trawl towlines were mapped from start to end point and demonstrated a marked enhancement of fine-scale fishing effort resolution, with increased ability to identify effort shifts over benthic habitat. Distinct spatial shifts in fishing intensity (measured as km towed) away from rock habitat were evident at all reference sites, with an average reduction of 86%. Some slight shifts into surrounding unconsolidated sediments also occurred, indicating effort displacement as well as reduction. Fishing intensity was calculated from commercial trawl and research trawl survey towlines to achieve the most accurate assessment of fishing impacts and potential habitat recovery areas. Research trawling intensity was less than 1% of commercial trawl effort originating from the same sites. A brief comparison of Oregon

vessel towlines and California vessel towlines demonstrated similar targeted fishing patterns by both fleets, except at one site.

Results indicate that the footrope restriction, in conjunction with associated landing limits, was effective in protecting rocky habitats from trawl fishing impacts. Reference areas were identified where essential fish habitat (EFH) recovery is likely occurring off the coast of Oregon. Substantial regulatory changes continue in this fishery, with trip limits and gear restrictions continuously adjusted. Continued monitoring and review of spatial trawl data would assist in fishery management decision-making and assess conservation objectives for depleted groundfish and associated habitats. Future research should incorporate analysis of catch data and expand the review of trawl towlines for the entire US West coast groundfish fishery. The trawl towline spatial analysis developed in this work is a credible method for reviewing fishing effort at the scale of the fishery and in relation to detailed habitat data. The research presented here provides an example of how an interdisciplinary approach and critical assessment of data can work to resolve marine management challenges.

INTRODUCTION

There has been substantial concern over the effects of bottom-trawling and other fishing activities on benthic ecosystems and the sustainability of fish populations (Dieter et al. 2003, Johnson 2002, NRC 2002, Kaiser and de Groot 2000, Rester 2000, Thrush et al. 1998, Watling and Norse 1998, Jones 1992). Because bottom-trawling can alter essential fish habitat (EFH), it is important to understand fishing patterns both spatially and in the context of fishery management. It is imperative that fishery management measures implemented to protect depleted groundfish species and their associated habitat be critically evaluated as to their success. In the absence of such evaluation, there is no means to determine whether habitat conservation objectives are being met or what role regulatory actions play in recovering fish populations. Previous studies reviewing the effects of Pacific groundfish management have rarely assessed spatial or habitat specific implications (Babcock and Pikitch 2000, Gillis et al. 1995, Pikitch 1987, Pikitch and Melteff 1987).

Advances in the application of geographical information systems (GIS) now offer the capability to effectively analyze and evaluate spatially-related fishery management concerns (Valavanis 2002, Kruse et al. 2001, Meaden 2000, Isaak and Hubert 1997, Meaden 1996, Meaden and Chi 1996). The use of GIS improves our ability to form spatially appropriate biological and management related questions and to determine if present data sets can adequately address these questions. This tool allows for the synthesis of broad-scale spatial data sets from multiple disciplines. Spatial changes due to biological significance or regulatory decision-making can now be viewed simultaneously. As a spatial analysis tool, GIS is especially adapted to aid in management functions at various scales for monitoring of change, comparative studies (spatial and temporal), and modeling projection scenarios.

Primary management measures used to mitigate fishing impacts on habitat include regulating gear use, controlling landing limits for targeted fish (to reduce overall fishing effort and therefore frequency of disturbance), and by restricting or closing geographical areas to particular gear types. To date, the Pacific Fishery Management Council (PFMC) has implemented a combination of all three methods for the US West coast groundfish trawl fishery to protect and rebuild depleted rockfish (*Sebastes spp.*) populations (65 FR 221, 67 FR 57973). Many rockfish species are associated with hard-bottom, high-relief rocky areas (McCain 2003, Love et al. 2002). Habitat sensitivity to fishing impacts from mobile trawl gear is thought to be greatest in these stable areas of high habitat complexity (substrate surface topography) with a prominent degree of biogenic cover (Kaiser et al. 2003, Kaiser et al. 2002, Auster and Langton 1999, Auster 1998). Recovery appears to be most rapid in habitats which are less physically stable (i.e., sand), in contrast with rocky areas (Collie et al. 2000). Although these rocky areas are often the target of conservation concerns, very little attention has been given to the study of fishing impacts and recovery in these hard-bottom habitats in the Pacific Northwest.

The primary objective of this study was to examine trawl effort shifts over benthic habitats in response to regulatory changes in the US West coast groundfish fishery. In particular, this study focused on a PFMC-mandated restriction in trawl footrope size for landing nearshore and shelf rockfish species as well as most flatfish species. This regulation, enacted in 2000 to shift fishing incentives, linked various groundfish trip limits to large (> 8 inch (> 20.5 cm) diameter) and small (≤ 8 inch (≤ 20.5 cm) diameter) footrope configurations (65 FR 221 1/4/00, PFMC 2000, PFMC 1999). The composition of a small footrope could not exceed 8 inches along its entire length, which includes discs, attachments, or any other materials applied to the footrope cable and/or chain. Fishermen were also prohibited from attaching chafing gear to small footrope configurations. By inhibiting the large footrope gear necessary to pass over rough terrain and obstructions, this restriction was designed to redirect fishing effort off of high-relief rocky areas where depleted rockfish species are most abundant. Furthermore, the retention of most fish normally caught in these areas was prohibited if using large footrope gear to reduce the incentive to fish in these areas. The effort it would take to fish these areas and the large amounts of fish that would have to be discarded would make fishing economically unfeasible. Previous studies by Hannah (2003, 2000), based solely on catch information, indicated that a reduction in fishing effort had occurred after the trawl footrope restriction, but did not determine any relationship to benthic habitat. Hannah (2003) also recognized that the landing limits connected to footrope size may also play an important role in the reduction of trawling.

Comprehensive maps of seafloor lithology along the west coast of the United States have recently been compiled. Goldfinger et al. (2003) assembled and interpreted existing geological and geophysical data for the Oregon continental margin, which was made available for this study. The resolution and accuracy of the lithology data vary because of the non-uniform availability of data sources. An assessment was provided using ranked data distributions which allowed for the review of input data quality and suitability for habitat mapping (Romsos 2004). Oregon marine geomorphological features are identified in Figure 1 with an overlay of the seafloor lithology data. The width of the continental shelf is very narrow (~17 km) at Cape Blanco in southern Oregon and generally widens going north to Cape Falcon (~ 61 km). The boundaries of these Oregon lithology data extend from the Washington border at 46° 15' 00" N latitude to the California border at 42° 00' 00" N latitude. The eastern boundary is the intertidal zone and the western boundary is the edge of the continental slope (~ 3000 m depth). The system used to describe surficial geologic habitat types was a modification of the classification described by Greene et al. (1999). Benthic habitat, as defined for this study, refers to the surficial lithologic units dictating substrate type as described by Romsos (2004). While broader definitions of "habitat" may encompass many other ecological and abiotic factors, this study uses the structural substrate component as a proxy for associated benthic fish communities.

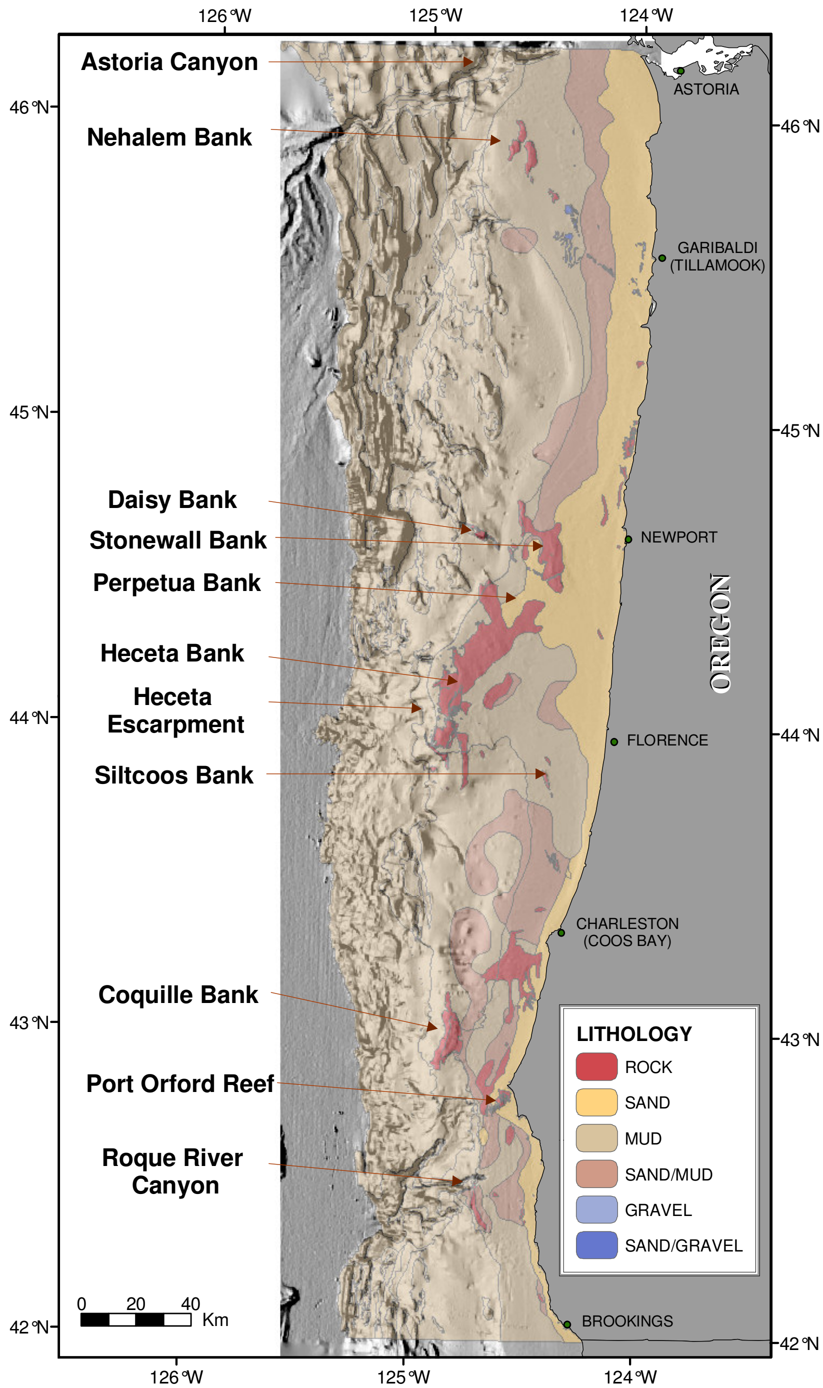


Figure 1. Oregon marine geomorphological features noted by shaded bathymetry and associated seafloor lithology. Seafloor lithology is shown with 50% transparency and units are further described by Romsos (2004) and Goldfinger et al. (2003).

The spatial resolution of fishing effort is determined by the reporting of information by the fishery. To appropriately address different management issues, the proper resolution is required. Data collection procedures for the US Pacific West coast groundfish fishery include a tri-state trawl logbook program (Sampson and Crone 1997). Trawl logbooks contain fishing location information, but prior to 1997 spatial resolution was poor because many locations were reported as the center point of large (10 x 10 nautical mile) geographical blocks. Reporting fishing effort as the number of tows per block ignores the possibility that tows are not homogeneously distributed throughout the block. Trawl fishing effort is known to be concentrated in particular areas with patchy distribution (Ragnarsson and Steingrimsson 2003, Marrs et al. 2002, Kulka and Pitcher 2001, Auster and Langton 1999, Rijnsdorp 1998), and benthic habitats occur on a finer, more detailed scale than that of traditional reporting blocks. This contributes to potential bias when applying data values over coarse scale blocks or grids (Rose 2002b unpublished manuscript, Larcombe et al. 2001, Piet et al. 2000, Pitcher et al. 2000, Rijnsdorp 1998). Spatial resolution of fishing effort has also been limited in Oregon and Washington because electronic conversion of paper logbooks results in only the trawl start location being entered into electronic databases. A single point can limit our ability to review spatial patterns at the scale of actual fishing practices (e.g., tows can cover large distances, overlap, and cross grid cells). This present research utilized methods for adequately reviewing spatial relationships between targeted, patchy fishing effort and benthic habitat features.

This study was focused exclusively in Oregon waters and consisted of several components. First, an analysis of spatial and temporal shifts in trawl fishing effort over benthic habitat was performed using available trawl start locations for the entire study period (1995-2002). This provided an initial spatial understanding of where increases and decreases in fishing effort occurred related to habitat distribution and fishery management measures. Second, precise tow end-point information was retrieved from manual logbooks for five reference sites located in the proximity of rock habitat features (1998-2001). Trawl towlines were then mapped from start point to end point for finer scale resolution of fishing locations to enhance the examination of fishing effort shifts over benthic habitat. Finally, fine scale spatial shifts in relation to the 2000 footrope restriction were then reviewed using complete trawl towlines. A brief comparison of Oregon vessel towlines and CA vessel towlines was also made to assess any spatial variations by fleet. Fishing intensity (measured as km towed) was calculated from commercial trawl and research trawl survey towlines to achieve the most accurate assessment of fishing impacts and potential habitat recovery areas. The outcomes of this study are expected to reveal how management measures might influence trawl fishing effort shifts to aid in habitat conservation, methodologies to effectively evaluate the extent of habitats affected by bottom-fishing disturbances, and to emphasize the benefits of increasing the spatial resolution of fishery data.

METHODS

Commercial trawl logbook data were obtained for the limited entry groundfish fishery from state databases maintained by the Oregon Department of Fish and Wildlife (1995-2002), the Washington Department of Fish and Wildlife (1995-2001), and the California Department of Fish and Game (1995-2001). Washington and California data were filtered so that only trawls which occurred off the coast of Oregon were represented. Oregon data were not requested with any geographical restriction and records extended into both Washington and California waters. These logbook records were removed from the analysis during the process of spatially joining annual effort layers with a benthic habitat layer that exclusively covered the Oregon coast, from approximately latitude 46°15'30" N to 42°1'0" N. A single logbook record consisted of the parameters for an individual trawl tow, including information pertaining to the vessel, date, time and location of tow, gear used, and catch. This study included only those trawl tows using gear which comes in contact with the seafloor. Unfortunately, it was impossible to review specific bottom trawl gear types used before and after the footrope restriction due to the inconsistency of gear codes recorded by different states and the confounding use of a non-specific groundfish trawl gear code before 2000. Logbook records were dropped from the analysis if they were recorded using a midwater gear configuration, were recorded as the central point of a 10 x 10 nautical mile statistical reporting block rather than an actual tow location, or if a starting location was reported over any landmass. The application of these filters removed approximately 15% of Oregon logbook records, 25% of California logbook records, and 69% of Washington logbook records (Table 1). Removals were attributed primarily to records reporting use of midwater gear. In the case of California, central reporting block locations resulted in the removal of all records from 1995-1996.

Spatial analysis and mapping were conducted with ArcGIS Desktop version 8.2 by Environmental Systems Research Institute (ESRI). The analyses included use of the ArcINFO workstation, various ESRI extensions, and additional software tools. Data layers created and used in this study were all standardized using the same projected coordinate system (UTM Zone 10N) and datum (WGS 1984) to minimize spatial error in the analysis. In this projection, the central meridian is placed within the center of interest to minimize distortion of spatial properties in that region. It is best suited for north-south areas, such as the U.S. Pacific west coast, which conveniently falls along the center of Zone 10N.

Locations where trawl fishing begins, referred to as the set of each tow, were mapped for each year and by state. Trawl set locations from all three states were then combined into annual point (vector) layers of fishing effort. Oregon habitat polygons (rock, gravel, gravel/sand, sand, sand/mud, mud) (Figure 1), as described by Romsos (2004) and Goldfinger et al. (2003), were spatially joined to annual point layers using an identity function to compute the geometric intersection between data layers. The number of tows per year per habitat type was then summarized.

Table 1. Records filtered from raw database records that were provided by each of the three states. Resulting annual record totals were then used for analysis. Records were removed if the trawler used midwater gear, the set location was recorded as the center of a statistical reporting block, or the set location was noted over a landmass. Note: California and Washington data were only requested for those logbook records which occurred in Oregon waters.

Filter Applied	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**	**Total**	**% of Total**
Oregon	18459	18787	18129	15719	13557	11670	11579	8716	116616	
Midwater Gear	1885	1965	1907	1467	1700	2103	1417	679	13123	11.25%
Center of Block	1520	1678	665	27	19	0	0	0	3909	3.35%
Over Landmass	39	53	74	33	85	53	2	4	343	0.29%
Outside of OR Waters	5500	4939	4520	4694	4011	3215	3235	3096	33200	28.47%
Final Records for Analysis	9515	10152	10963	9498	7742	6299	6935	4941	32845	
Washington	52	46	56	17	25	103	60	N/A	359	
Midwater Gear	26	41	28	10	25	58	43	N/A	231	64.35%
Center of Block	16	7	0	0	0	0	0	N/A	23	6.41%
Over Landmass	0	0	0	0	0	0	0	N/A	0	0%
Final Records for Analysis	10	5	28	7	0	45	17	N/A	112	
California	428	445	511	833	627	474	340	N/A	3658	
Center of Block	428	445	13	2	1	1	0	N/A	890	24.33%
Over Landmass	0	0	3	1	1	0	3	N/A	8	0.22%
Final Records for Analysis	0	0	495	830	625	473	337	N/A	2760	

To observe the spatial shift in fishing effort between years, each annual trawl set point layer was converted to a continuous surface (raster) layer based on point density within the same geographic extent. A density calculation measures the number of trawl set points using a uniform areal unit (such as a square kilometer) to create a density value for each cell in the resulting layer to identify patterns where trawl set points are concentrated. Several parameters affect the resulting density surface and patterns, including the density unit, search radius, and cell size. A kernel density calculation per square kilometer was used with a 5,000 meter search radius and an output cell size of 100 m^2. Square kilometer density units adequately reflect fishery scale features (Kulka and Pitcher 2001). The search area dictates the distance within which points are found to calculate the density value assigned to each cell in the output raster layer. The search diameter used in this calculation was later verified to be within the average towline length of the fishery and thus matches the scale of fishing patterns. The output cell size determines how fine or coarse the pattern appears. Using a kernel density calculation, rather than a uniform "simple" calculation gives a smoother density surface with easily detected patterns. Density values were calculated to distribute trawl set points throughout a landscape for each year and then subtracted between years to observe areas of increased and decreased fishing effort.

Five case-study reference areas were selected by comparing spatial patterns of fishing effort with benthic habitat type (Figure 2). Four sites were selected which contained both rock habitat and significant fishing effort (Site 1-4). One additional site was selected based on a bathymetric structure, the Rogue River Canyon, with a greater proportion of soft sediment habitat and significant fishing effort (Site 5). Concentric buffers at specified distances from the same central point, with diameter size increasing by 1 km intervals, were reviewed to determine the most appropriate size for selecting trawl set points and habitat polygons at each site. The ideal size buffer for each site was then used to select the trawl set points within it for further data retrieval. Two adjoining buffers were used to select the southern-most site for optimal coverage of fishing effort patterns, which could not be adequately represented by a single symmetrical buffer. A subset of Oregon logbook records was created for each reference site (Table 2). Additionally, the quality of rock habitat data was assessed within each site buffer using ranked distributions of data density and quality developed by Romsos (2004). The order of rock habitat quality values ranked Site 1 as the highest, followed closely by Site 2 and Site 4 with equal values, Site 5 with a moderate value and Site 3 with the lowest value.

Tow end locations, referred to as haul points, for each site's subset of records were manually retrieved from paper logbooks held by the Oregon Department of Fisheries and Wildlife office in Newport, Oregon. A protocol was developed to assure data confidentiality and quality control. Logbook records which did not contain haul location information (4% of all reference site records) were removed from the analysis.

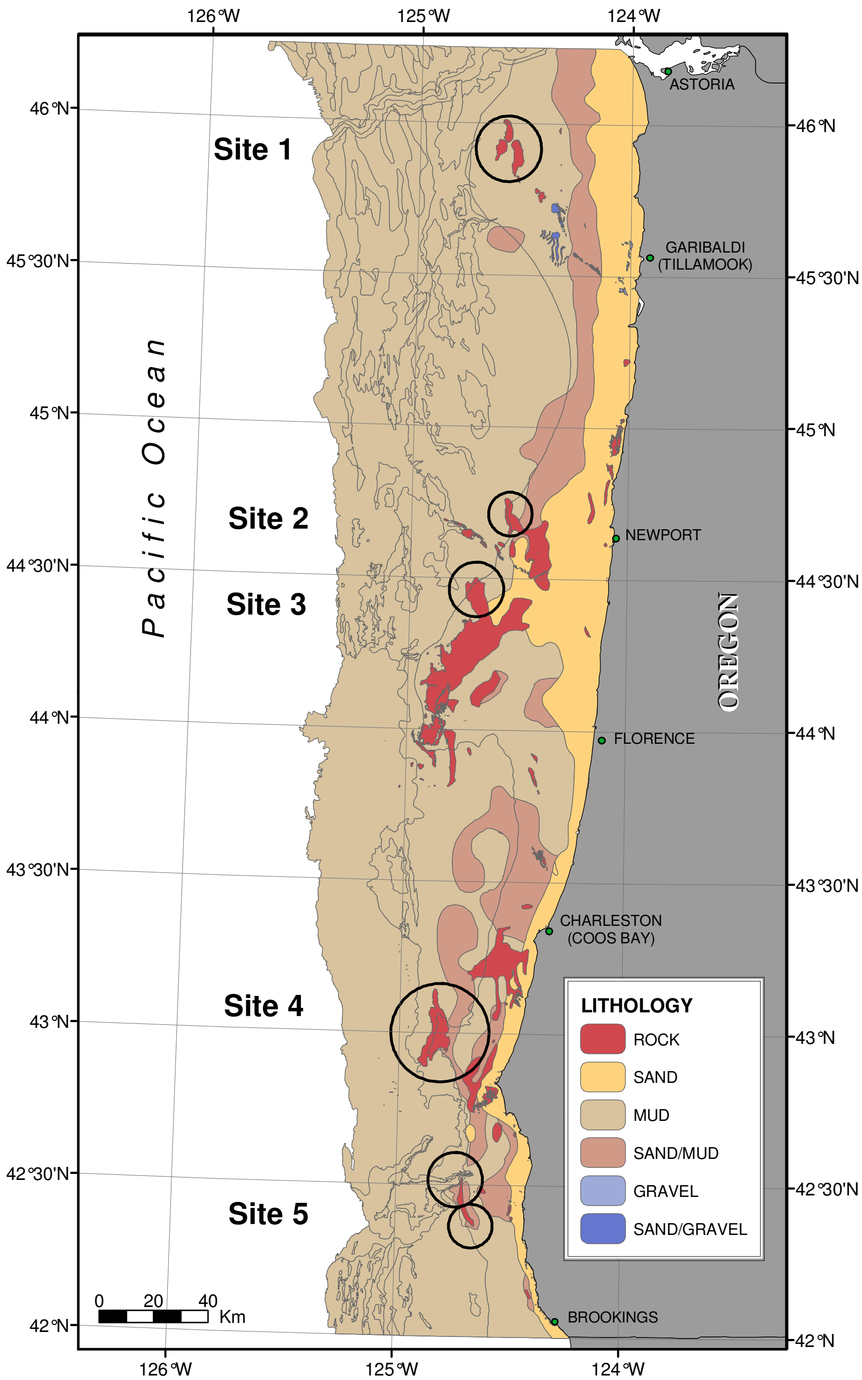


Figure 2. Location of reference sites (Site 1-5) in proximity to rock habitat features on the continental shelf off the west coast of Oregon, USA. Benthic habitat data are represented in the lithologic units described by Goldfinger et al. (2003). Reference site buffers (**O**) indicate the area within which trawl start (set) locations were selected for further retrieval of trawl end (haul) locations in manual logbooks.

Table 2. Description of five selected reference sites and logbook records from within these sites used to construct trawl towlines by retrieval of tow haul (end) locations. Filtering steps that were applied to identify and remove unsuitable records for this study are noted.

	Site 1	Site 2	Site 3	Site 4	Site 5
Site Selection Buffer Diameter (km)	24	16	20	36	20 & 16
Mean Reported Site Depth (fathom)	102	94	101	160	166
Minimum Reported Site Depth (fathom)	51	53	60	39	50
Maximum Reported Site Depth (fathom)	250	185	320	650	600
Selected OR Logbook Records	326	538	1442	1551	1350
Haul Location Missing	26	28	30	84	48
Haul Location Identical to Set Location	0	6	7	3	3
Haul Location Over Landmass	0	0	1	5	1
Selected CA Logbook Records	-	-	-	71	429

Records with haul locations identical to the tow set location or for which trawling occurred over a landmass were also dropped from the analysis (< 0.5 %).

Haul locations were mapped with the corresponding set location. Trawl towlines were created using a Visual Basic script which draws a straight line from each set location to each corresponding haul location. The azimuth of each towline from true North (0°) was calculated using an expression (polyline_Get_Azimuth.cal) in the ArcMap attribute table field calculator. The length of each towline was measured to estimate the distance traveled. Towline length was used to predict vessel speed based on the logbook-reported tow duration. This was done to determine if towline distances could have been traveled within a realistic range of towing speeds. An overlay of trawl towlines across benthic habitat type subsequently split each towline into multiple segments at each habitat boundary and joined the attributes of the underlying habitat type to each towline segment using an identity command. The length of each resulting towline/habitat type segment was measured by updating feature topology. Towline segment lengths were then summarized annually by habitat type and compared across years. Patterns of trawl towlines were reviewed in both a spatial and temporal context.

Swept area calculations, defined as the amount of ground potentially contacted by trawl gear, were not made for the purposes of this study in part due to the absence of detailed trawl gear notation in logbooks and the wide variety of gear used in the fishery. Often "average" gear parameters are used in calculations for the purposes of estimation. The detailed spatial distribution of trawl towlines and towline distance measurements can provide similarly acceptable information in regard to fishing intensity.

California state database logbook records from 1997 to the present contain the location for both tow set and tow haul. California records were used for a comparison with the spatial and temporal patterns observed in towlines originating from Oregon logbook data. Subsets of California logbook records were created for the two southern reference sites (where OR/CA fishing effort overlapped) using the same site buffer selection and clip method (Table 2). California subsets were then mapped and processed using the same methodology as the Oregon reference site records noted above.

Research trawling has occurred off the Pacific coast since 1977 in the form of NMFS groundfish surveys. Trawl towlines were mapped for groundfish research survey tows. Research trawling (conducted during both continental shelf and slope surveys) which originated within reference site areas accounted for only a small fraction of total fishing effort. Fishing intensity (measured as kilometers towed) by research vessels was less than 1% of that exhibited by commercial fishing vessels during the same time period (1998-2001). Therefore, research trawling information was not considered in subsequent analyses.

Groundfish management measures for the limited entry trawl fishery were tabulated from the Federal Register for the time period 1995-2002. Acceptable Biological Catch (ABC), Optimal Yield (OY), and annual allocation to the commercial trawl fishery were recorded by year for each managed species or fish assemblage. Cumulative trip limits were organized and recorded by month. In-season changes to trip limits were added to these tables for each management change during the course of a year. This compilation of temporal management measures provided the basis by which corresponding fishing effort distributions were reviewed.

RESULTS

A decreasing trend in annual trawl fishing effort off the Oregon coast was observed across all years from 1997-2002 (Table 1). Directed fishing effort in Oregon waters by Washington vessels was concentrated along the Oregon-Washington border and diffused in a southerly direction. There was a greater amount of effort in Oregon waters by California trawlers than from Washington trawlers. California trawl effort demonstrated a similar trend as the Washington vessels, with effort concentrated at the Oregon-California border and diffusing gradually in a northerly direction.

Trawl fishing effort differed by location and intensity in proximity to the major rocky bank features on the Oregon continental shelf (Figure 1). Trawl set points for the entire study period fell within mapped seafloor lithology, which extended to approximately the 3000 m depth contour. Trawl set points over Nehalem Bank occurred predominantly over portions of the bank located farthest offshore. On Stonewall bank, there was a concentration of set points along the north to northwest slope-edge of the bank, but very few over the main bank. Cape Perpetua bank had a similar concentration of set points around the northwest slope-edge portion of the bank, but again very few points over the main bank. Trawl set points are found throughout the Heceta Escarpment, the slope-edge feature just offshore of Heceta Bank, with only a few points appearing over the southern tip of the actual bank itself. Siltcoos Bank did not have any associated trawling activity. Coquille Bank displayed set point patterns northwest of the main bank, to the north, south and west of the bank, with a lesser density of set points over this bank as well. Orford reef is a nearshore feature which did not experience any documented trawling activity.

In addition to an overall decline in effort, there were shifts in the number of trawl sets between years and between habitat types. The number of trawl sets per habitat type was consistent with the total area of habitat type available, i.e. the majority of trawl sets took place in the largest geographically mapped habitat type - mud (Table 3). The smallest extent of mapped habitat, gravel habitat, did not contain any trawl set locations, though it is still possible that trawl tows may be crossing into this habitat designation. A reduction in tows within all habitat types took place from 1997-2000. In 2001 and 2002, there was a distinct increase in both the number of tows and proportion of tows in sand habitat relative to 1998-2000. The proportion of tows in sand/mud habitat remained steady from 1997 to 2001, then increased in 2002. Tows in mud habitat were steady in 2000 and 2001 but significantly decreased in both number and proportion in 2002. Tow sets in rock habitat decreased in both 1999 and 2000, with the proportion of tows in rock habitat decreasing significantly during 2000. Tow sets in rock habitat increased in 2001 and slightly decreased again in 2002, but still remained at much lower levels than before 2000.

Broad scale spatial shifts in trawl fishing effort were apparent across years, as visualized by density maps (Figure 3). The spatial distribution of areas experiencing increases and decreases in fishing effort between years are summarized in Table 4. Areas of increased fishing effort were still evident in each between-year calculation, despite the overall decline in trawl tows each year. This provided clear evidence that trends or shifts in effort are occurring which were not attributed solely to the decrease in annual tow numbers. Shifts in fishing effort were at times extremely patchy and at other times somewhat continuous in distribution. One such continuous distribution is a decrease in fishing effort along the outer continental shelf in 2002 from fishing effort which occurred in 2001. This is in part attributed to the first full depth-related spatial closure of the fishery from approximately 100 to 250 fathoms in September of 2002 (67 FR 57973).

Table 3. Results of the geographic overlay of tow set point locations and corresponding habitat type. Results are noted as both the number and proportion of tow set locations over each habitat type. The total mapped area of each habitat type (km^2) is also included.

Lithologic Unit Habitat Type	Total Area of Habitat (km^2)	Tow set locations								
		1995	1996	1997	1998	1999	2000	2001	2002	Total
Sand/Mud	4,236,923	1170	1398	1493	1520	1240	986	990	949	7178
Sand	5,922,956	610	664	912	653	582	350	625	968	4090
Mud	32,555,575	7081	7217	8343	7423	6219	5428	5560	2927	35900
Rock	1,756,087	599	849	725	733	313	52	105	93	2021
Gravel	7,489	0	0	0	0	0	0	0	0	0
Gravel/Sand	37,606	65	24	13	6	13	2	0	0	34
		Porportion of tow set locations								
		1995	1996	1997	1998	1999	2000	2001	2002	Total
Sand/Mud		0.123	0.138	0.130	0.147	0.148	0.145	0.136	0.192	0.146
Sand		0.064	0.065	0.079	0.063	0.070	0.051	0.086	0.196	0.083
Mud		0.743	0.711	0.726	0.718	0.743	0.796	0.764	0.593	0.729
Rock		0.063	0.084	0.063	0.071	0.037	0.008	0.014	0.019	0.041
Gravel		0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Gravel/Sand		0.007	0.002	0.001	0.001	0.002	0.000	0.000	0.000	0.001

Table 4. Summary of increasing and decreasing trawl fishing effort calculated by subtracting an annual set location density layer from the density layer of the previous year, calculated for each year pair between 1997 and 2002.

Annual Difference	Increased Effort	Decreased Effort
1998-1997	Largely located from central to southern OR on the continental margin between 100-200 m contours, with patchy distribution along the entire margin.	Patchy decreases observed from nearshore to deep offshore regions, but concentrated mostly along the northern border west of Astoria and extending into central OR along the 200 m contour.
1999-1998	Concentrated along the northern border west of Astoria with additional light increases in deeper water offshore along the entire margin.	Concentrated in a semi-solid band from Depoe Bay to the southern Oregon border along and just inshore of the 200 m contour.
2000-1999	Primarily located in the northern region both along the 100 m contour and in deeper offshore waters past 300 m.	Several concentrated areas are west of Astoria and Newport and also in the southern region from Bandon to Brookings between the 100-300 m contours.
2001-2000	From the northern border to central OR between the 200-300 m contours with several patches centrally located along the 100 m contour. Additional patches are located between Bandon and Port Orford.	Noted in the northern region along the 100 m contour and also offshore in deeper waters both north and south of Heceta Bank.
2002-2001	Only several small patches are noted in the northern region, two west of Astoria (<50 m and at 100 m) and one between Netarts and Pacific City from the 50-100 m contours.	Observed in a large band along the entire continental margin focused at the 200-300 m contours.

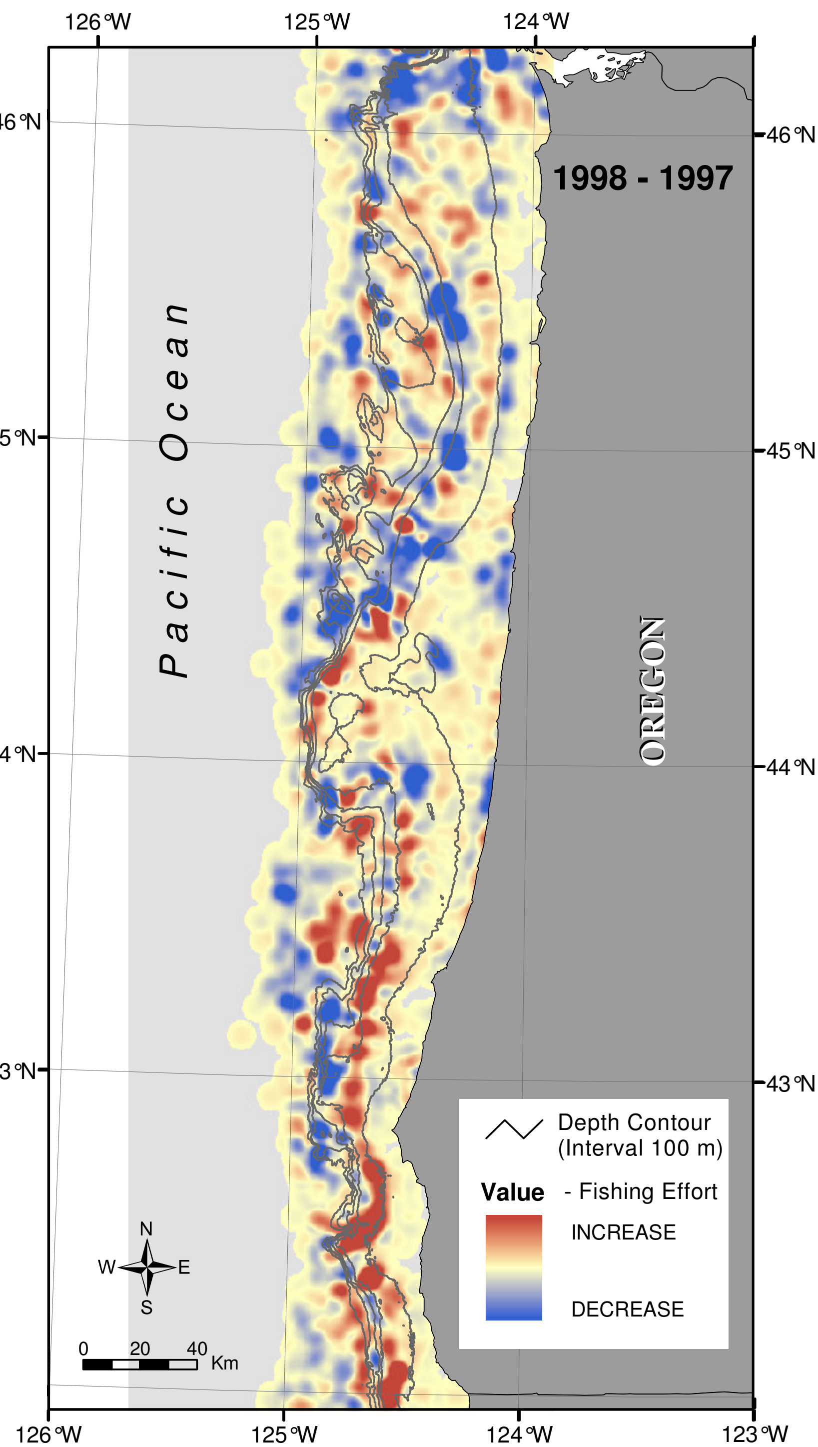
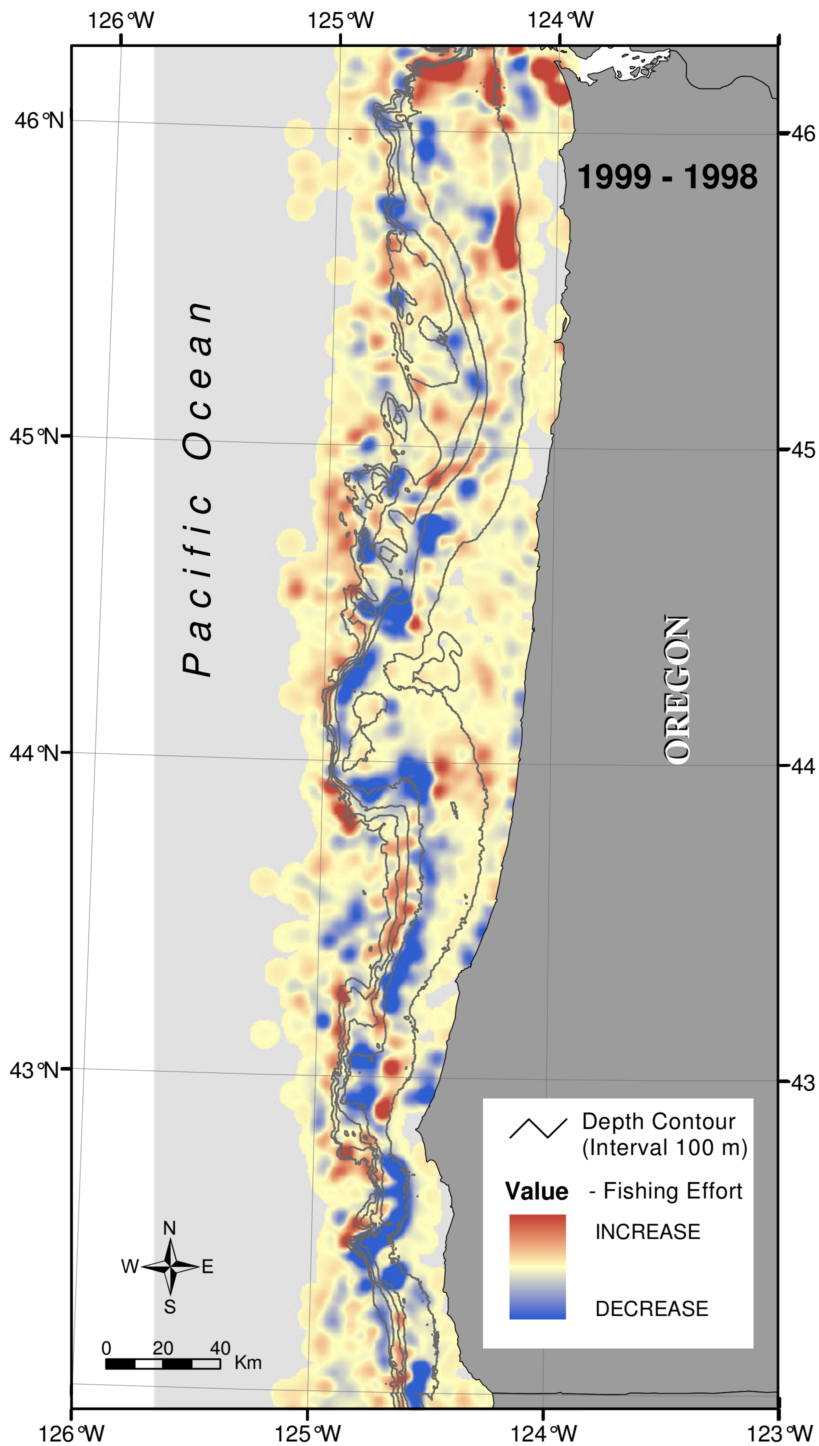


Figure 3. Density maps of the extent and degree of increase or decrease in trawl fishing efforts represented from the difference between annual trawl set point densities. Density values are calculated in the same geographic extent for each individual year and then subtracted between two consecutive years to observe areas of increase (red), no change (yellow), or decrease (blue). Depth contours (100-500 m) are noted to delineate the continental shelf and slope and areas with no data value are represented in grey.



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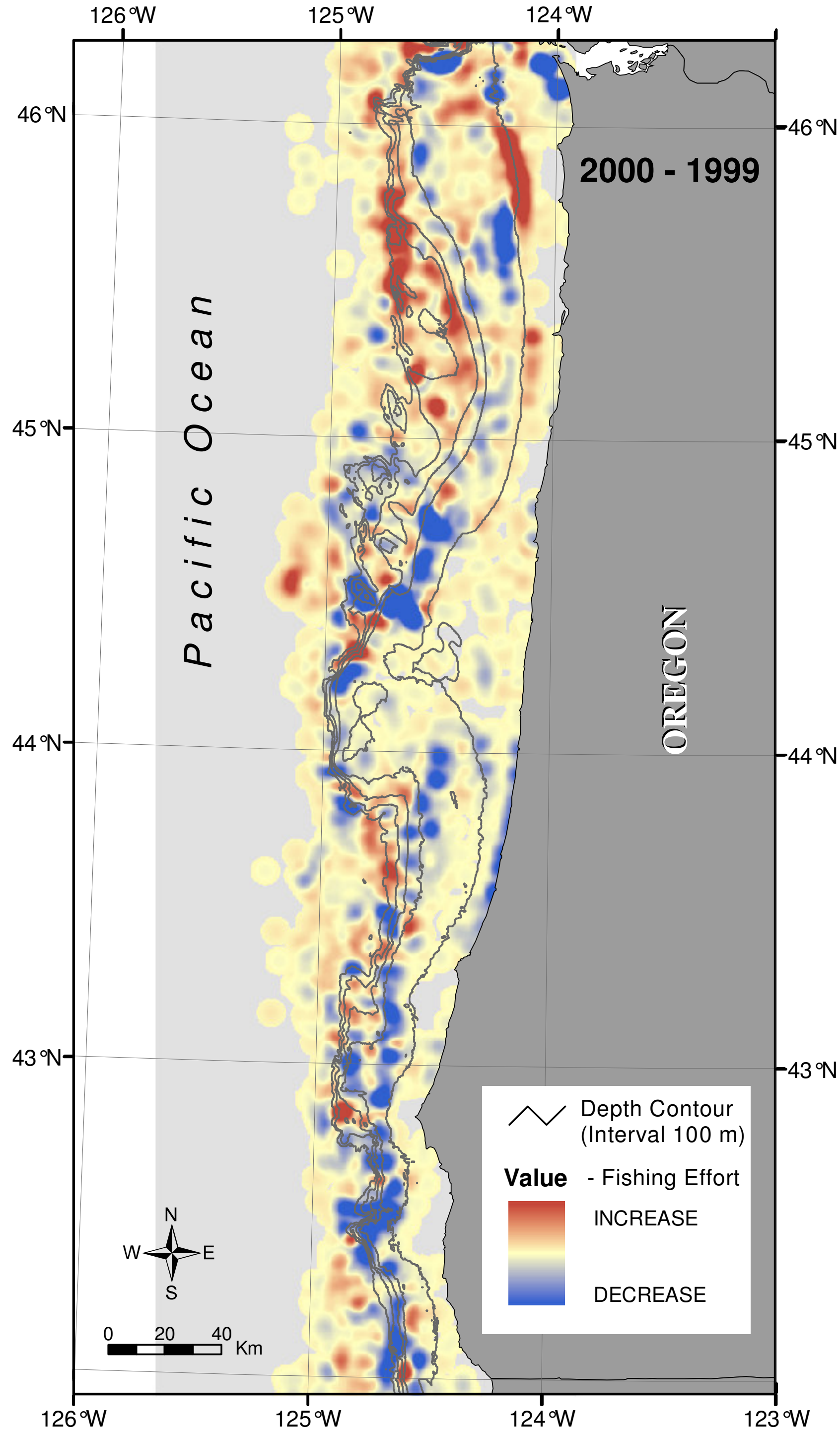

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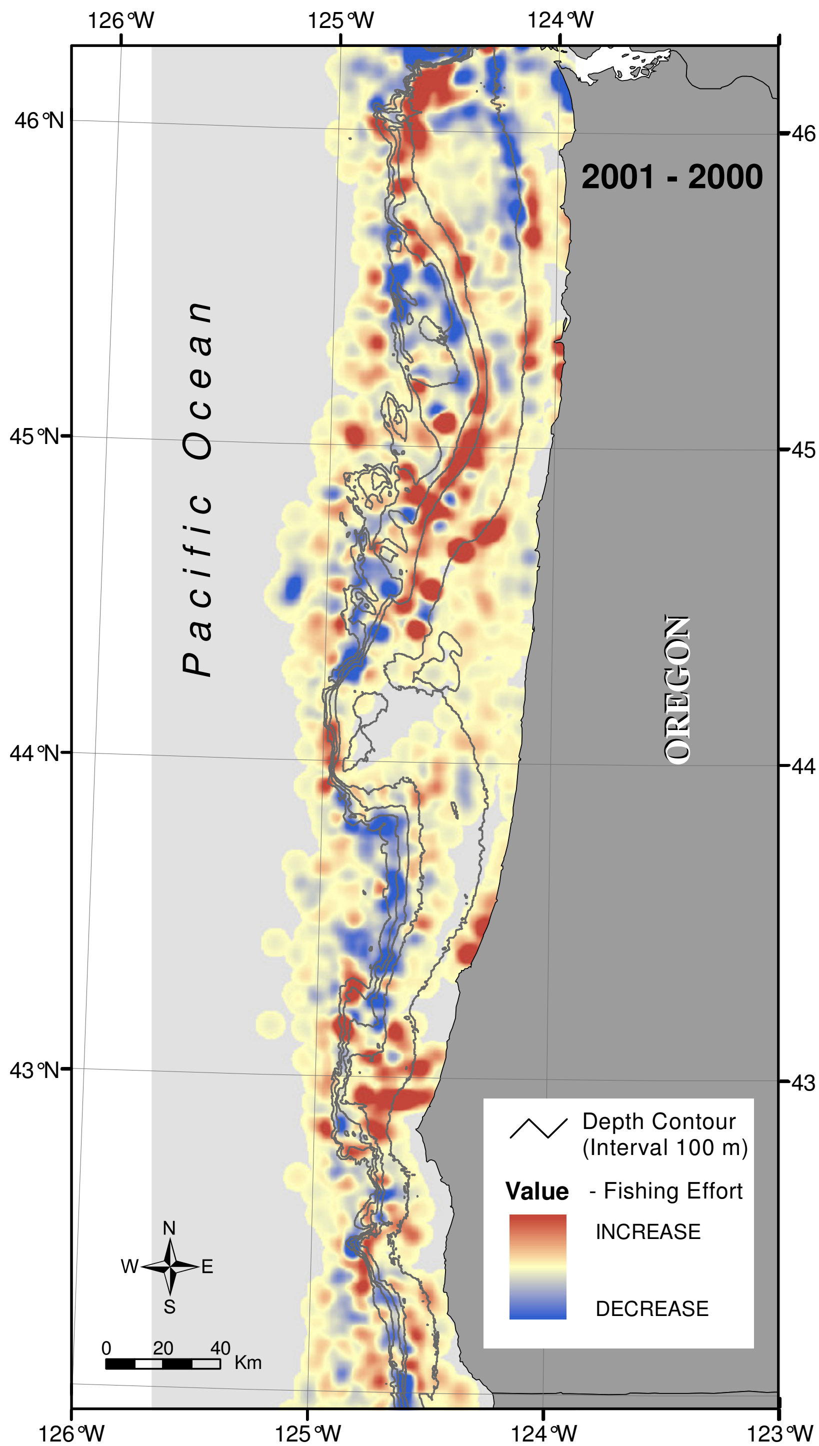

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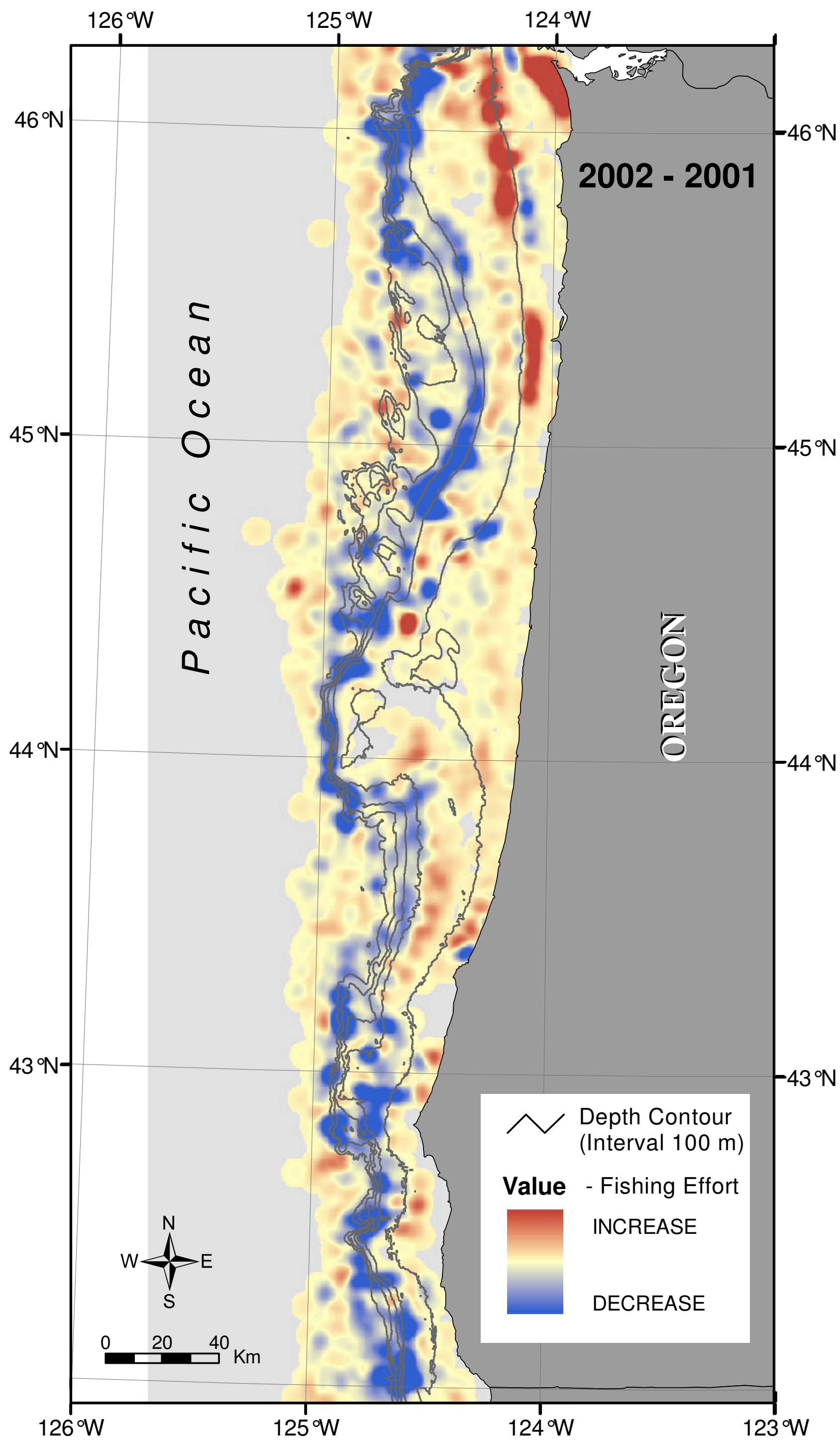


Figure 3. *Continued.*

The use of trawl towlines created for each reference site demonstrates a substantial improvement in the resolution of fishing effort data relative to the use of start point locations alone (Figure 4). Towlines also depict the direction of towing and the distance towed. Towlines provide an enhanced visual representation of spatial patterns in the variability of trawl towing behavior relative to habitat, bathymetry, and direction. Based on an azimuth calculation from true North (0°) for each towline, the majority of towlines are positioned within northern (315° to 45°) or southern (135° to 225°) directional quadrants (Table 5). Predicted vessel speeds derived from towline length and logbook duration fell within a realistic range of tow speeds established from interviews conducted with fishermen. This evidence supports the assertion that the trawl towline model is a close proximity to reality. This model cannot determine the exact path trawled but does appear to be a rather close proxy. The straight-line towline model is a conservative estimate of actual distances trawled due to the many factors which prevent towing in exactly straight lines.

Table 5. The percentage of reference site trawl towlines that lie within directional quadrants based on their azimuth (calculated from true North (0°)).

	Site 1	Site 2	Site 3	Site 4	Site 5
North-South Quadrant (315° to 45° and 135° to 225°)	90%	77%	84%	89%	65%
East-West Quadrant (45° to 135° and 225° to 315°)	10%	23%	16%	11%	35%

The ability to detect changes or shifts in spatial fishing patterns over habitat was greatly enhanced by the towline model. Spatial shifts in fishing effort away from rock habitat were strikingly evident for all reference sites after the 2000 footrope restriction (Figure 4). Fishing intensity was summarized as the kilometers towed per year for a given habitat type. Total distance trawled over each habitat type was pooled for the two years prior to the footrope restriction (1998-1999) and the two years after its implementation (2000-2001) (Table 6). The number of split towline segments that occurred over each habitat type exemplifies the difference between just counting the number of total trawl tows in an area and getting an estimate of actual fishing distances covered over each habitat. Decreasing fishing intensity and a decreasing number of towlines segments over rock habitat is demonstrated for all five reference sites after the footrope restriction. Fishing intensity decreases were greatest after the footrope restriction at Site 2 (93.7% reduction) and Site 1 (93.6% reduction). Site 5 demonstrated a 90% reduction followed by reductions of 84.8% at Site 3 and 69% at Site 4. Increasing fishing intensity is shown over mud habitat at reference sites 1 and 4 although the number of towline segments decreases slightly. Smaller increases occur over sand habitat at reference site 1, 3 and 4. Reference site 3 demonstrates a small increase in towing distance over sand habitat, despite a decrease in the number of towline segments represented.

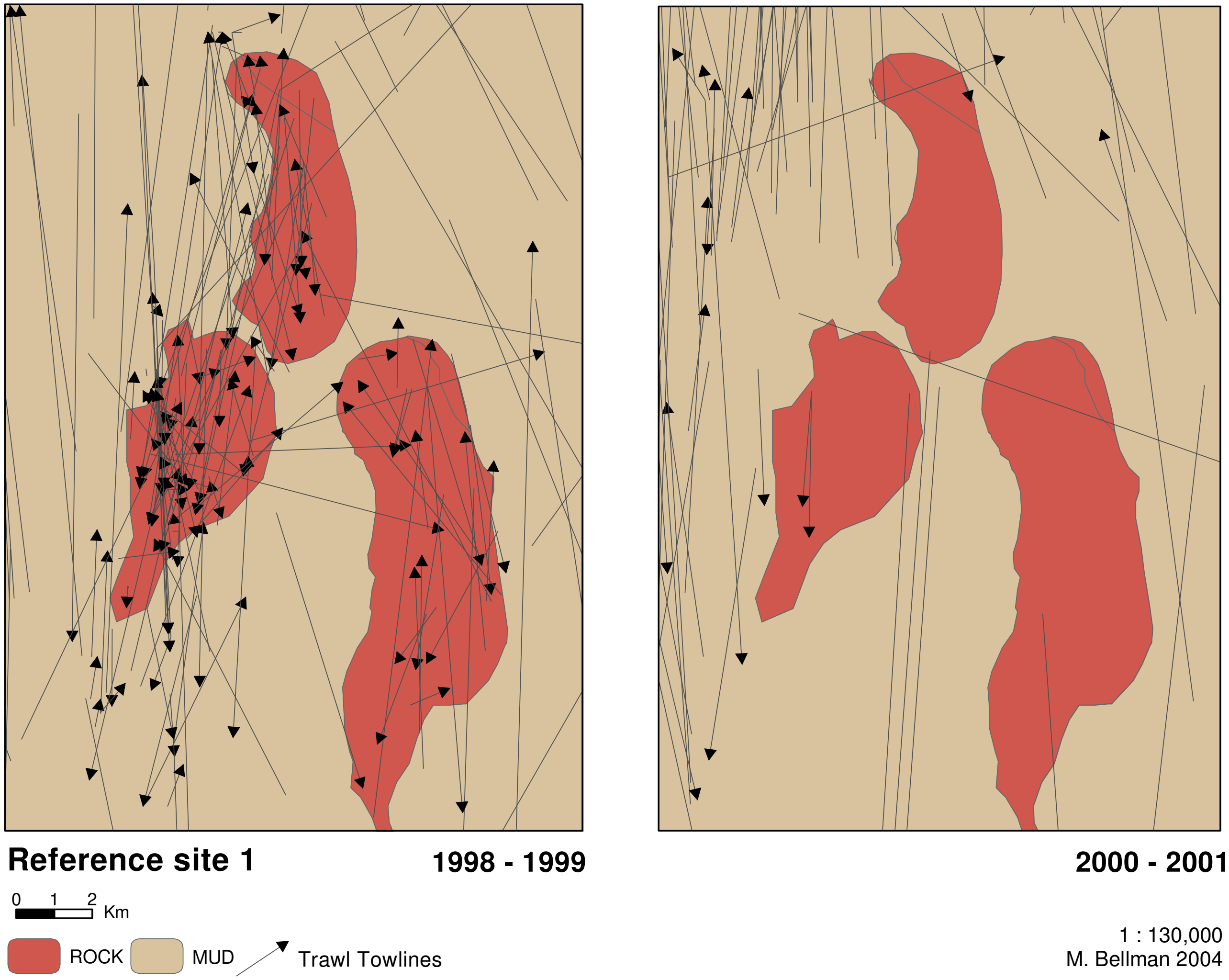
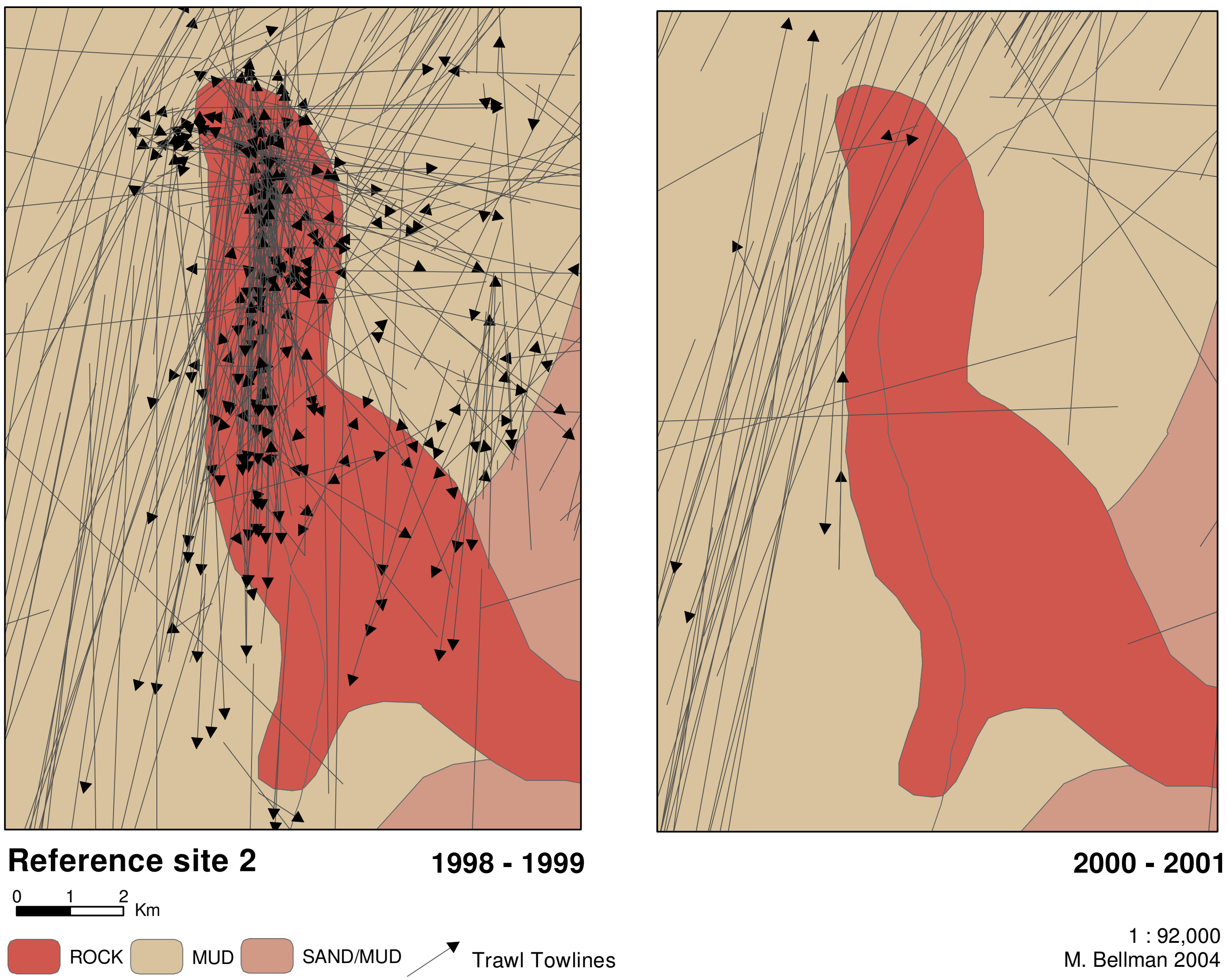


Figure 4. Spatial shifts in trawl effort away from rock habitat at five selected reference sites before (1998-1999) and after (2000-2001) the footrope restriction. See Figure 2 for reference site locations. Note scale changes between sites.



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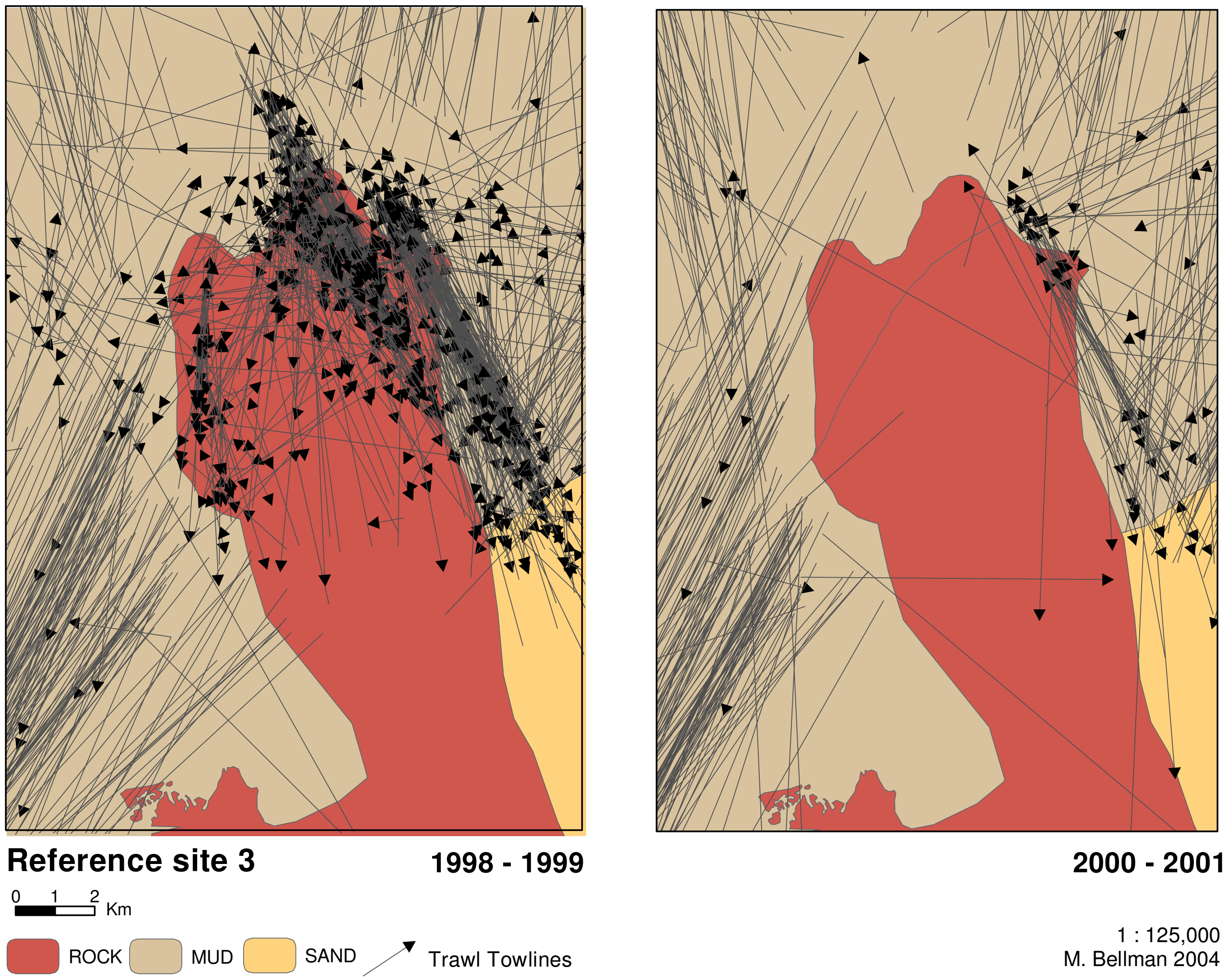

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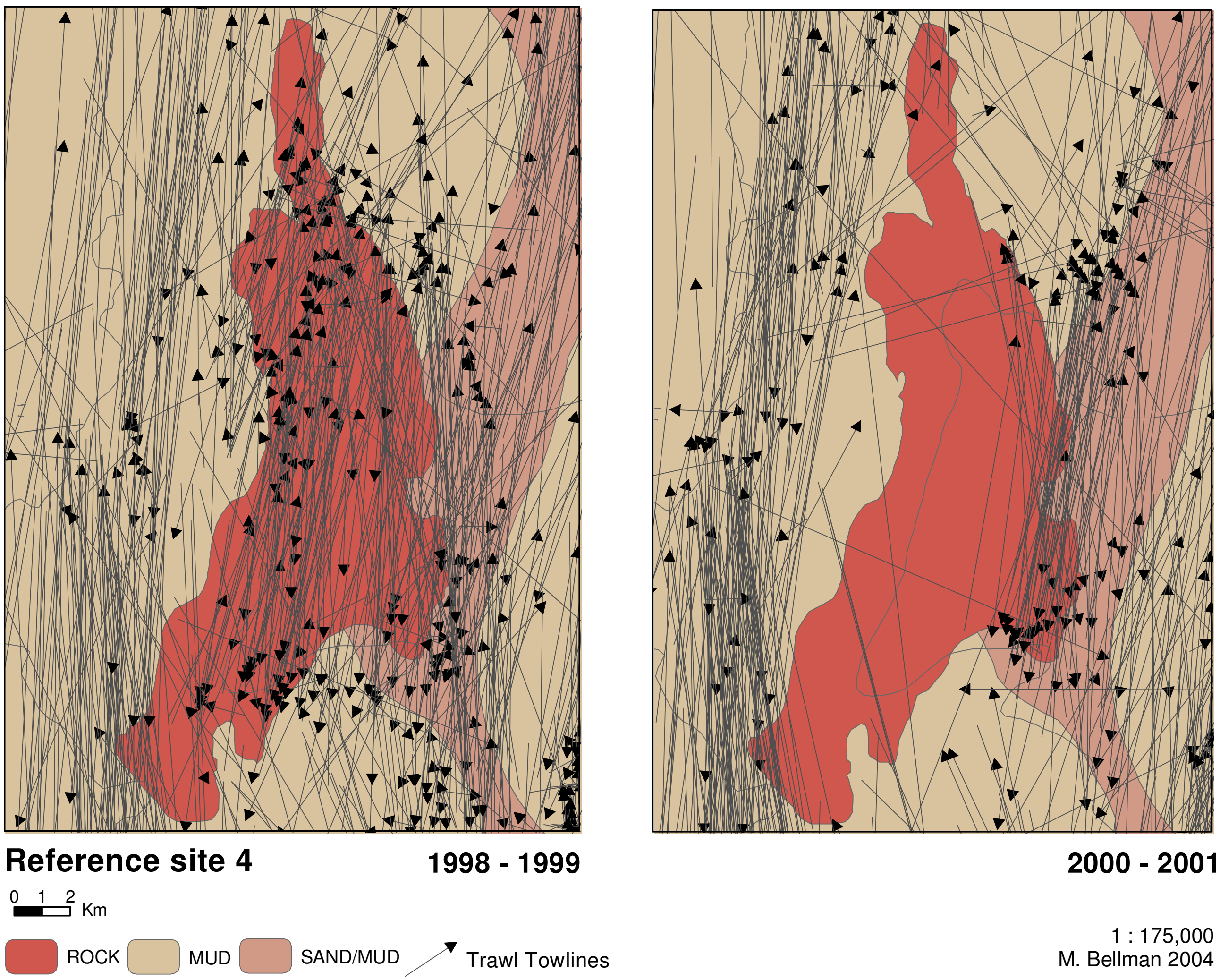

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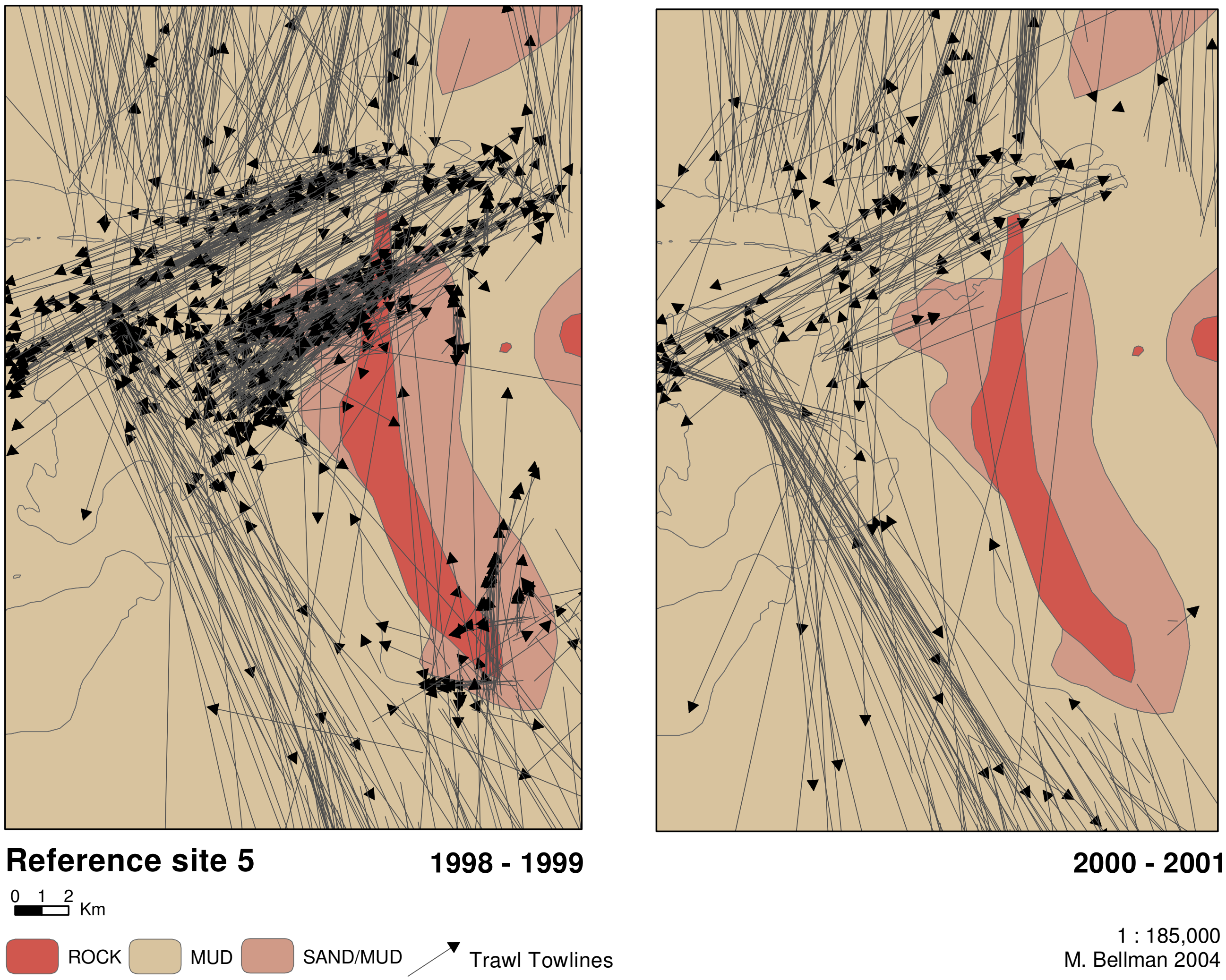

Figure 4. *Continued.*

Table 6. Total trawl towline distances (km) and the number of towline segments over benthic habitat type before (1998-1999) and after (2000-2001) the footrope restriction. A towline segment represents one section of a towline. Each towline was split at each habitat polygon boundary (i.e. multiple towline segments can be created by splitting a single individual towline).

	Towline Distances (km)											
	Rock			Mud			Sand			Sand/Mud		
Reference Site	1998-1999	2000-2001	% Change	1998-1999	2000-2001	% Change	1998-1999	2000-2001	% Change	1998-1999	2000-2001	% Change
Site 1	403	25	-93.6	1340	2071	54.6	0	10	> 100.0	39	51	29.7
Site 2	764	49	-93.7	1977	1402	-29.1	70	7	-89.4	518	300	-42.0
Site 3	1670	253	-84.8	6487	5731	-11.6	116	124	6.9	17	2	-88.4
Site 4	2049	636	-69.0	6924	7243	4.6	7	15	94.3	1929	1807	-6.3
Site 5	232	22	-90.4	7763	4913	-36.7	40	18	-54.5	1057	150	-85.8
	Towline Segments											
	Rock			Mud			Sand			Sand/Mud		
	1998-1999	2000-2001	% Change	1998-1999	2000-2001	% Change	1998-1999	2000-2001	% Change	1998-1999	2000-2001	% Change
Site 1	450	37	-91.8	224	205	-8.5	0	1	100.0	8	9	12.5
Site 2	166	16	-90.4	402	133	-66.9	12	3	-75.0	90	54	-40.0
Site 3	906	135	-85.1	1329	760	-42.8	102	62	-39.2	2	1	-50.0
Site 4	579	257	-55.6	1436	1340	-6.7	2	5	150.0	469	483	3.0
Site 5	203	12	-94.1	2638	1163	-55.9	18	6	-66.7	553	41	-92.6

In general, Oregon and California towline patterns for reference site 5 are consistent but Oregon vessel towlines demonstrate two additional spatial patterns. Oregon vessels also trawl within and along the length of the canyon and over an area just south of the canyon at depths of approximately 150-200 m. These trawl patterns are closely associated with the bathymetric features of the Rogue River canyon. The canyon's east-west orientation reflects the higher percentage of towlines in reference site 5 positioned within east and west directional quadrants (Table 5). The majority of California tows began north of the canyon and trawling occurred in a northerly direction. A second group of tows by California vessels began in the southwestern section of the upper site 5 selection buffer and towed south along the 400 m contour. The third group of tows by California vessels began in the southwestern section of the lower site 5 selection buffer at depths greater than 150 m and trawled in a southeasterly direction. California towlines in reference site 4 were consistent with Oregon towline patterns. Most of the California set points were located in the southern half of the site 4 selection buffer and trawling occurred in a southerly direction.

DISCUSSION

There is significant inter-annual variability in trawl fishing effort. These inter-annual shifts are affected by factors such as changes in target species, management trip limits, and fishing strategies (Sampson 2001, Babcock and Pikitch 2000). Overall, fishing effort exhibited patchy distribution and maintained similar statewide patterns over the entire study period. This consistency is common when fishermen return to areas previously known to harbor high abundances of target species and suitable seafloor for trawling.

From a conservation standpoint, this patchiness may be desired if fishing efforts do not also expand into the unaffected areas. Patchy distribution of trawl effort disturbs the same areas of seabed frequently, but in turn leaves large areas unaffected by the impacts of fishing gear. Spatial management measures, such as closed areas, can have the effect of shifting fishing activity to areas that were previously lightly fished or very rarely fished (Holland 2003, Rijnsdorp et al. 2001). The mitigation of a closed area should be carefully weighed against resulting redistributions of fishing effort. Larcombe et al. (2001) demonstrated that a general increase or redistribution in trawl fishing effort unrelated to closed areas tended to concentrate in those relatively small, high-effort areas rather than expanding into new fishing grounds. From fine-scale spatial analysis it is possible to identify if fishing effort is localized to a small area versus the same amount of fishing effort that is spread out over a larger area. Fishing impact and recovery studies have not clearly addressed how the dynamics of these two different spatial patterns of fishing effort might relate to various habitats. In the context of conservation, these dynamics may depend upon which habitats or non-target species are located within already targeted fishing grounds. Conservation objectives tend to target habitat types or species particularly sensitive to fishing pressure. The evaluation of spatial effort distributions within various habitats will be a critical component in executing management decisions for conservation objectives.

Density mapping created views of aggregated fishing effort which closely reflected habitat-related patterns. These are usually undetected by grid methods, unless the grids are perhaps set at very fine scales (i.e. 1 x 1 km cells). A grid method basically splits geographical space into a pattern of arbitrarily sized cells and assigns fishing effort homogeneously within each cell. Cell size has a large influence on the results of such work. Cell size can either be too small and fishing practices overlap into multiple cells, or too large and assigned fishing effort is too broadly distributed. Another main concern is that grid cells are often unable to reflect the spatial complexity of geographic features, such as habitat boundaries, an issue addressed by this work. To avoid extrapolation, a density calculation requires the use of parameters that are within the scale of the fishery. The search diameter used in this study (radius = 5 km) was within the average distance of trawl towline lengths (average = 11.86 km). Density mapping greatly facilitated the identification and extent of particular habitat areas that were experiencing changes in fishing pressure, which aided in the selection of study sites.

Another brief consideration is that density mapping provides an easily aggregated view of trawl start locations, which is often necessary when working with any confidential fishery-dependent data. Confidentiality concerns can still be addressed by this method and yet the spatial resolution of fishing effort patterns is improved.

This density mapping technique was validated in a non-experimental manner when it was discovered that decreasing fishing effort density directly overlaid a continuous depth range along the entire length of the Oregon coast between 2002 and 2001, a result of a spatial closure in the fishery. In September of 2002, a large portion of the continental shelf off Oregon, from approximately 100 to 250 fathoms, was closed to trawling to protect overfished darkblotched rockfish (*Sebastes crameri)*. Even though this closure was only reflected in the study data for four months at the end of the fishing year, it nevertheless was revealed as a marked decrease in fishing effort in relation to that which occurred in 2001 throughout the closure boundaries.

The use of trawl towlines rather than set point locations resulted in the analysis of fleet responses to management measures at an appropriate spatial scale. Towlines provide a basis by which to observe patterns of fine scale yet realistic fishing effort. Based on this analysis, it is crucial that in the future all haul location data be entered into electronic databases from fishery-dependent collection programs. Because haul locations have been and are currently provided by fishermen in paper logbooks, it would require only a minimal cost to include this field in data entry. The effort to review and process spatial data on an annual basis would provide not only an additional quality control step by verifying realistic reporting of fishing location, but would also allow evaluation of current spatial management measures. Although this study focused on five reference sites off the Oregon coast, this work could easily be expanded to examine all trawl logbook data for the US West coast.

The spatial shift of tow patterns away from rock habitat was distinctly evident from visualization of trawl towlines after the 2000 PFMC footrope restriction (Figure 4). Towline analysis also provided a measurement of trawling intensity by habitat type. The reduction in reference site towing over rocky habitat was both visibly evident and clearly measured by intensity with an average – 86 % change (Table 6). The reduction in effort over rocky habitat did not simply result in an overall reduction in fishing effort. Some fishing effort also slightly shifted from rock habitat to surrounding areas of unconsolidated sediments. Impacts in areas where *increased* fishing effort is occurring should be studied to assess the accompanying unintended consequences of this management action.

Several models of fishing activity have attempted to evaluate connections to the economics of fleet reduction, the study of marine protected areas, resource depletion, and the prediction of long-term responses to regulatory strategies (Scholz et al. 2003, Caddy and Carocci 1999, Maury and Gascuel 1999, Walters and Bonfil 1999). Such models would benefit from the fine tuning that trawl towline analysis can provide by accurately representing the distribution of fishing effort in geographic space.

We observed a majority of north-south tow directions, with the exception of east-west towing related to the Rogue River Canyon bathymetry in southern Oregon. This supports previous observations by Friedlander et al (1999) of trawl marks on the seafloor commonly orienting parallel to bathymetric contours. Spatially stratified exploration should therefore be conducted to locate bathymetric contours which may affect tow patterns prior to assuming a north-south tow direction in models of fishing effort.

Trawl gear disturbance on the seafloor can be examined through the use of high-resolution side-scan sonar (Friedlander et al. 1999, Krost et al. 1990), but the towline model can better quantify fishing effort over the use of trawl tracks seen with side-scan sonar. The path covered by a trawl, or trawl track, is often visible as a long, narrow, linear depression. Side-scan sonar is costly and the detectability of trawl tracks is heavily dependent on timing of the side-scan survey and the time at which fishing occurred, while trawl towlines display fishing activity at the scale of the fishery and provide an enduring (if indirect) record of potential trawl tracks. However, these two methods may prove complementary. Reviewing trawl towlines may provide the first step for identifying areas where high fishing impact disturbance occurs and trawl marks could then be examined closely with the use of side-scan sonar to verify fishing impacts and logbook positional accuracy to some degree.

The results indicate that the footrope restriction, in conjunction with associated landing limits, was effective in protecting rocky habitats from trawl fishing impacts. This supports previous demonstrations that gear changes or modifications can achieve some purposeful level of conservation (Valdemarsen and Suuronen 2003, Rose et al. 2002a unpublished manuscript, Van Marlen 2000). Fishery managers often only manage for direct habitat conservation by the force of conservation legislation or if it was demonstrated that a loss of habitat would directly lead to a loss of yield in the fishery. Similarly in this case, although the footrope regulation was only indirectly aimed at habitat conservation, it ultimately served this purpose.

Future extensions of this research will need to incorporate analysis of catch data to clarify the effects of gear restriction versus trip limits. One possible method described by Larcombe et al. (2001) apportions catch equally along the length of a towline and then summarizes catch within a fine-scale grid of 1 km^2 cells. Branch et al. (2004, unpublished manuscript) utilizes a clustering method related to trawl towline locations and associated catch data, which could then be used to delineate groups of tows in specific areas and their associated target species. This would be particularly useful information for various patterns of towlines identified at or near the rocky banks examined in this study.

This study directly assessed the effects of a previous management action, which is not often done in the context of fishery management today. Substantial regulatory changes have occurred in the last decade which have ultimately resulted in a reduction in trawl fishing effort off the Oregon coast. Effort shifts can be studied on any time step, from arbitrary (i.e. 1 year) to more natural steps, like regulatory regime shifts. Tracking of regulatory change by species provides the foundation to spatially examine individual management measures in a multi-species groundfish fishery. Fishery management compilation tables created for this study have been valuable tools in both research and outreach. It is recommended that this type of systematic tracking be instituted formally as a required exercise for management purposes and that these materials should be made readily available to all stakeholders. The tracking of fishery management change should be accompanied by a follow-up evaluation of the outcomes of fishery management actions.

Trip limits and gear restrictions associated with the original 2000 footrope regulation have since been adjusted. It will be necessary to continue monitoring responses in fishing effort to evaluate sustained habitat protection. Depth-based spatial management closures were implemented in September 2002 and related closures continued into 2003. Rock habitats within reference sites were not protected by these depth-based closures until May 2003. Therefore, the observed patterns in fishing effort reviewed here were solely based on previous management strategies. Potential habitat recovery from trawl impacts on rocky habitats in the studied reference areas began prior to the full spatial closure. It is very likely that in the near future these depth-based restrictions will be lifted in some areas or to some fishing gears and habitat protection will continue to vary as closure boundaries shift.

Reference site areas have been identified where EFH recovery is likely occurring off the coast of Oregon. These reference sites should be studied *in situ* as soon as possible to begin answering fundamental questions regarding recovery rates of habitat in the absence of trawling. There is a lack of published literature regarding both trawl impacts on rocky habitat and its recovery upon removal of these impacts (Kaiser et al. 2002, Collie et al. 2000). The largest research gaps are in determining event-response relationships as a function of gear, recovery time, and habitat type – especially in naturally stable, structurally complex habitats such as rocky reef habitat. For benthic communities that have experienced chronic fishing disturbance, it is not known whether eventual recovery to a "former" (often unknown) state will occur if fishing is halted, or if the system might have reached an alternative stable state from which it cannot simply return following removal of fishing disturbances (Holling et al. 1995, Holling 1973). It is generally thought that at high fishing effort levels, initial reductions would decrease impacts marginally but that benefits would be more apparent as effort declined even further (NRC 2002). The reference sites identified in this study can be used in further studies to provide additional insight in understanding such concepts.

Identifying both the distribution of benthic habitat types and the spatial extent and intensity of fishing effort is critical for evaluating where fishing gear impacts take place and how this in turn affects associated fish populations and their habitats (Johnson 2002, Meaden 2000). “Habitat” as defined in this study is fairly limited in the framework of groundfish EFH. Numerous studies have shown correlations between demersal fish and various classifications of seafloor substrate (Nasby-Lucas et al. 2002, Yoklavich et al. 2000, McRea et al. 1999, Stein et al. 1992, Hixon et al. 1991, Matthews 1989). New information on other aspects of fish-habitat associations could be incorporated, such as depth, temperature, salinity, biogenic structure, and nutrient or prey availability. By integrating new information on seafloor substrate at finer scales or by including ecological habitat factors, examining the effects of fishing effort distribution and intensity in the context of EFH would be enhanced.

Results also demonstrate the necessity of improving the spatial resolution of fishery data to address current fishery management concerns. Limitations on spatial precision are ultimately tied to the accuracy of the original positions recorded in logbooks. The precision of location using GPS is an improvement over Loran A and C, which were the shore-based navigation systems used prior to the implementation of GPS. Spatial precision works to the fisherman’s advantage because they can place their gear more accurately with the aid of GPS chart-plotters and supplementary acoustic equipment (Molyneaux 2002). Since the mid-1990’s, the spatial precision of logbook data has benefited from the use of GPS, requiring records of actual tow location in trawl logbooks, and from observer’s independent monitoring of fishing activities. Implementation of electronic vessel logbook systems to monitor fisheries would be effective in providing accurate and timely spatial data to improve fisheries management (Meaden 2000, NRC 2000). These systems would also shorten the lag time that currently occurs in the availability of data for management purposes. An electronic logbook system would facilitate utilization of spatial data on fishing catch and effort as a means to directly evaluate management of the fishery. Vessel monitoring systems may assist in verifying spatial location and patterns of fishing from individual tows, but this would require linkage to detailed fishing logbooks that host all of the other fields of data associated with a fishing tow and particular fishing trip (Kemp and Meaden 2002, Marrs et al. 2002, Rijnsdorp 1998). At this point in time, VMS systems in the U.S. West coast groundfish fishery may not be useful for management purposes other than basic enforcement of spatial area violations. Other fishing patterns, such as lifting trawl doors and resetting the same tow in a different direction, circular tows, etc, can be better addressed from detailed trawl track data from position loggers or frequent transmission of VMS vessel location data. Until then, trawl towlines are one method by which we can improve fishing effort resolution.

The issue of logbook and fishing effort confidentiality may need to be addressed in light of recent spatial management measures and enforcement, as well as the idea that fisheries are intended to be managed as a public-trust resource. Potential bias generated from any changes in confidentiality (i.e. misreporting) would need to be addressed.

Certainly, care should be taken in selecting the use of GIS methods for analyzing confidential data which is intended for aiding in the decision-making process to avoid any public presentation of sensitive data in the resulting maps. The overhaul of data-gathering and regulatory policies should include considerations for performing spatial analysis of fleet distributions and fishing effort to better assist in sustainable long-term fisheries management (Walters and Martell 2002, Pitcher 2001, NRC 2000).

Though extensive information is contained in logbooks, these data have been underutilized in fisheries management (NRC 2000, Starr and Fox 1996). This study's use of fishery-dependent logbook data demonstrates the extensive geographic and temporal coverage that these data contain relative to fishery-independent data sources. Research survey tows originating from reference sites were less than 1% of the fishing intensity by commercial tows selected from the same sites. Observer coverage and increases in collaborative research are incorporating more fishery-dependent data sources into the management arena (NRC 2004). Examining the previous year's fishing data before considering changes to regulations may work to alleviate concerns by fishermen that fishery managers do not value the information they provide (Gilden and Conway 2002, Kaplan 1998). With the recent shift to a two-year groundfish management cycle through Amendment 17 to the groundfish FMP, this can now be a realistic expectation when setting future policies and regulations.

The degree of interchange and support between associated marine disciplines such as fisheries oceanography, benthic habitat mapping, stock assessment, fishery database development, and spatial analysis is of critical importance for facilitating the evaluation of fishery management. With increasing environmental awareness, spatial relationships in marine fisheries management are developed by reaching agreements between often conflicting demands. Various stakeholder interests must be clearly represented to achieve optimal spatial balances in marine fishery-related issues. This study emphasizes the types of analysis and data needed to better inform the decision-making process for finding an optimal spatial balance between habitat conservation and fishing effort.

CONCLUSION

The increasing incorporation of ecosystem perspectives into fishery management will require understanding the spatial dynamics of both fish populations and fishery exploitation. Recent concerns regarding essential fish habitat and the possible adverse effects of bottom-fishing practices on such habitat highlight the need for and integrated understanding of ecosystem dynamics and fishery activities. Careful review and monitoring of spatial data from the US West Coast groundfish trawl fishery can assist in evaluating the extent of habitat affected by fishing disturbances and which management measures influence habitat conservation. This study demonstrated that the 2000 PFMC footrope restriction and associated landing limits influenced the shifting of trawl fishing effort away from rocky habitat off the Oregon coast. These rocky banks, which serve as habitat for depleted rockfish (*Sebastes spp.*) stocks, are now protected from the impacts of trawling. Methodologies developed in this study highlight the benefits of increasing the spatial resolution of fishery data collection. The collection of fishery data should strive for fine-scale resolution to make use of new spatial analyses to better evaluate concerns of the diverse stakeholders in the marine environment. The evaluation of complex fishery management measures can utilize the spatial linkages of information on fish distribution, habitat, environmental parameters, and fishery exploitation. New information on relationships between fish and habitat type, advances in seafloor mapping and habitat classification, and ongoing changes in fishery management will each contribute valuable information to future analyses of this type. The research presented here demonstrates how interdisciplinary research and analysis can resolve marine management challenges today and provide insight regarding the spatial aspects of this challenge.

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Appendix 20

NMFS Survey HSP Data Comparison with the Life Histories Appendix

This paper reports on a preliminary comparison of the HSP data derived from the NMFS survey data for depth/latitude and the HSP data derived from the Life Histories Appendix (NOAA Fisheries 2003).

General Comments

By and large, the NMFS survey data (and hence the maps) seems to tie up reasonably well with the information in the Life Histories Appendix (NOAA Fisheries 2003). However, it became clear that the areas that had very low HSP values (below 0.01) derived from the NMFS survey data for depth/latitude, were unlikely to be suitable, and that it would be better to map them as zero. The areas which had HSP values between 0.01 and 0.1 roughly corresponded to the outer depth limits of the fish distribution as given in the Life Histories Appendix, which generally quotes the extreme limits (say 100m to 600m) and then the normal range (95% between 150m and 450m). These have been abbreviated in the following in the form (100)150-450(600).

The latitude information in the Life Histories Appendix is more vague, and generally gives only the extreme limits (often well outside our area). However, on the whole these seem to correspond with the HSP 0.01 level derived from the NMFS survey data for depth/latitude. Furthermore, where further information is given in the Life Histories Appendix (e.g. more common N of Monterey), these also seem to correspond with the HSP 0.1 level.

This suggests that the maps would be better if they treated the NMFS survey data HSP values lower than 0.01 as zero, and split the HSP 0.01 to 0.2 category at 0.1 to distinguish the extreme areas from more likely ones.

The habitat data corresponded pretty well to the Life Histories Appendix. However, two of the 18 fish were not represented in the habitat data (Aurora and Darkblotched - rockfish) so they had to be made up from (somewhat vague) information in the Life Histories Appendix.

Some fish had NMFS survey data depth/latitude HSP values that were all (or almost all) low. In particular, silvergray rockfish and flag rockfish had very low values. Some others only had HSP maxima of around 0.3 or 0.4. Is there a good reason for this? A related question is whether the NMFS survey data HSP data values should be rescaled so that the maximum value is 1.

Summary: Comparison for 18 individual species

In the following summaries, depth and latitude ranges are given as described above. The following abbreviations are used for habitat types:

Ss	Shelf, soft
Sh	Shelf, hard
Scs	Shelf, canyon, soft
Sch	Shelf, canyon, hard
Fs	Slope, soft
Fh	Slope, hard
Fcs	Slope, canyon, soft
Fch	Slope, canyon, hard
Bs	Basin, soft
Bh	Basin, hard

Habitat values are given as percentages (0 to 100).

Aurora Rockfish

Depth:	NMFS survey data - (100)250-650(750); Life Histories Appendix - (125)150-500(765)
Latitude:	NMFS survey data - low values in N, very high in S, all above 0.1; Life Histories Appendix - Vancouver Is to San Diego.
Habitat:	No data (assumed Ss, Fs, Bs = 100); Life Histories Appendix – deep, soft bottom.
Comment:	NMFS survey Depth data looks okay but main part of values are a bit too high. High values in south imply that distribution stretches well beyond San Diego. Should probably have made Scs and Fcs = 100 also.
Fit:	Dubious fit.

Bank Rockfish

Depth:	NMFS survey data - (70)190-460(540); Life Histories Appendix - (31)-(247). Adults prefer >210m.
Latitude:	NMFS survey data – (45)41 – south. Peak around 36-37 degrees; Life Histories Appendix – Newport, OR to central Baja California.
Habitat:	Fh, Sh = 100, Sch, Scs, Fch, Fcs = 66; Life Histories Appendix – hard bottom, high relief or bank edges, ledge of Monterey Canyon. Also deep water over muddy or sandy bottom. Adults also on rocky/non-rocky shelf, canyon, slope, basin.
Comment:	NMFS survey Depth data does not agree with Life Histories Appendix, but Life Histories Appendix may be wrong – adult depth range seems very narrow.
Fit:	Reasonably good.

Blackgill Rockfish

Depth:	NMFS survey data - (150)250-600(680); Life Histories Appendix - (219)250-600(768)m.
Latitude:	NMFS survey data – (49)41-southwards, highest between 36-37 degrees; Life Histories Appendix – About Washington (maybe further north) to Punta Abreojos.
Habitat:	Fh = 100, Fch = 83, Sh, Sch = 66; Life Histories Appendix – Rocky, hard bottoms. Edges of canyons, seamounts.
Fit:	Good fit.

Cowcod

Depth:	NMFS survey data - (30)110-290(380); Life Histories Appendix - (21)180-275(366). Just says “common” in range 180-275m.
Latitude:	NMFS survey data – Northwards to 41(47); Life Histories Appendix – Guadalupe Is, Baja California to Mendocino, CA.
Habitat:	Fh = 100, Sh, Sch = 66; Life Histories Appendix – High relief rocky areas. Submarine canyons?
Comment:	Generally a good fit, though NMFS survey latitude data goes too far north. Max data value only 0.38.
Fit:	Good fit.

Darkblotched Rockfish

Depth:	NMFS survey data - (30)60-480(590); Life Histories Appendix - (25)50-400(600)m.
Latitude:	NMFS survey data – Increasing northwards from about 33 degrees; Life Histories Appendix – Santa Catalina Is to Bering Sea.
Habitat:	No data (assumed Ss, Scs, Fs, Fcs = 100); Life Histories Appendix – Soft bottom. Rocks, boulders, cobble surrounded by mud.
Comment:	A good fit, provided the habitat is correct.
Fit:	Good fit.

Flag Rockfish

Depth:	NMFS survey data - (130)-(440); Life Histories Appendix - (30)-(183)m.
Latitude:	NMFS survey data – (32)-(39), (42)-(46); Life Histories Appendix – Heceta Bank, OR to central Baja California.
Habitat:	Sh = 100, Sch = 66; Life Histories Appendix – Hard bottom.
Comment:	No NMFS survey data values above 0.1. Life Histories Appendix states that it is an important sport fish in S California. Clearly NMFS survey data are wrong.
Fit:	Pure.

Greenspotted Rockfish

Depth: NMFS survey data - (30)60-360(480); Life Histories Appendix - 90-179(209)m.
Latitude: NMFS survey data – (46)41-south; Life Histories Appendix – Copalis Head, WA to Cedros Is, Baja California.
Habitat: Sh = 100, Ss = 83, Fh,Fs = 66; Life Histories Appendix – High relief rocky reefs and soft bottoms.
Comment: NMFS survey data give too great a depth. Otherwise a reasonably good fit.
Fit: Reasonably good fit.

Greenstriped Rockfish

Depth: NMFS survey data - (30)70-320(440); Life Histories Appendix - ?(50)150-239+(409)m.
Latitude: NMFS survey data – Increasing northwards over whole area; Life Histories Appendix – Cedros Is, Baja California to Alaska.
Habitat: Sh = 100, Ss=83, Fh,Fs = 66; Life Histories Appendix – Rocky and soft bottom, high and low reefs.
Comment: Some confusion in depth values Life Histories Appendix, the values given being contradictory.
Fit: Good fit.

Pacific Ocean Perch

Depth: NMFS survey data - (60)140-550(670); Life Histories Appendix - (25)100-450(825)m.
Latitude: NMFS survey data – (37)39 northward; Life Histories Appendix - Aleutians to La Jolla, common from Oregon northwards.
Habitat: Sh, Sch, Fh, Fch = 100, Ss, Scs, Fs, Fcs = 66; Life Histories Appendix – Gravel, rocky, boulders, gullies, canyons..
Comment: NMFS survey depth data looks okay. NMFS survey latitude data does not go as far south as La Jolla. Habitat looks okay.
Fit: ?

Redbanded Rockfish

Depth: NMFS survey data - (100)150-460(540); Life Histories Appendix - (49)150-450(625)m.
Latitude: NMFS survey data – (32)34 - north; Life Histories Appendix – San Diego to Bering Sea.
Habitat: Fs, Ss = 100; Life Histories Appendix – Soft substrate.
Comment: In Life Histories Appendix, latitude uncommon S of San Francisco.
Fit: Good fit.

Redstripe Rockfish

Depth:	NMFS survey data - (70)110-350(410); Life Histories Appendix - (12)100-350(425)m.
Latitude:	NMFS survey data – (32)41 - north; Life Histories Appendix – San Diego to Bering Sea.
Habitat:	Fh, Sh = 100; Life Histories Appendix – Rocky areas.
Comment:	There seem to be very few Life Histories Appendix polygons with suitable habitats where it has high NMFS survey data values. Is this correct?
Fit:	Good fit.

Rosethorn Rockfish

Depth:	NMFS survey data - (60)110-430(550); Life Histories Appendix - (92)100-350(550)m.
Latitude:	NMFS survey data – Increasing northwards over whole area; Life Histories Appendix – Guadalupe Is, Baja California to Alaska.
Habitat:	Fh = 100, Sh, Sch = 66; Life Histories Appendix – Rock habitat, boulders.
Comment:	As with the Redstripe rockfish, there seem to be very few Life Histories Appendix polygons with suitable habitats where it has high NMFS survey data values. Is this correct?
Fit:	Good fit.

Rougheye Rockfish

Depth:	NMFS survey data - (30)100-600(860); Life Histories Appendix - (25)50-450(875)m.
Latitude:	NMFS survey data – (34)41 northward; Life Histories Appendix - Aleutians to San Diego.
Habitat:	Sh, Ss, Fh, Fs = 100; Life Histories Appendix – soft, steeply sloped (rather unclear).
Comment:	NMFS survey depth data looks okay (perhaps a bit deep). NMFS survey latitude data looks fine, though not quite as far S as San Diego. Is it found on hard as well as soft?
Fit:	?

Sharpchin Rockfish

Depth:	NMFS survey data - (50)110-440(530); Life Histories Appendix - (25)100-350(475)m.
Latitude:	NMFS survey data – (32)34 - north; Life Histories Appendix – San Diego to Aleutians. Less common S of Monterey.
Habitat:	Sh = 100, Ss, Fs = 33; Life Histories Appendix – Can occur over soft, but prefer mud & cobble or boulder & cobble.
Fit:	Good fit.

Silvergray Rockfish

Depth:	NMFS survey data - (30)60-350(460); Life Histories Appendix - (0)100-300(375)m.
Latitude:	NMFS survey data – (38)41-north; Life Histories Appendix – Santa Barbara Is to Bering Sea, commercially important.
Habitat:	Sh, Fh = 100; Life Histories Appendix – Rocky bottom.
Comment:	Nearly all NMFS survey data values are very low. This does not seem consistent with the commercial importance, and implies that the species is rare below 41 degrees. Currently not believable.
Fit:	?

Splitnose Rockfish

Depth:	NMFS survey data - (30)70-510(590); Life Histories Appendix - ?(0)100-450(800)m.
Latitude:	NMFS survey data – Increasing northwards from about 33 degrees; Life Histories Appendix – Baja California to Alaska.
Habitat:	Ss, Fs = 100, Scs, Bs = 66; Life Histories Appendix – Non-rocky shelf, slope, basin.
Fit:	Good fit.

Yellowmouth Rockfish

Depth:	NMFS survey data - (110)170-380(500); Life Histories Appendix - (137)275-366(366)m.
Latitude:	NMFS survey data – (40)48 – north; Life Histories Appendix – Point Arena, CA to Alaska. Adults from N California northward.
Habitat:	Fh, Sh, Bh = 100; Life Histories Appendix – rough bottom, rocky shelf on slope, basin.
Comment:	Nearly all NMFS survey data values are very low, inconsistent with distribution in Life Histories Appendix, which also says that it is commercially important from BC to OR.
Fit:	?

BACKGROUND INFORMATION: FISHING REGULATIONS IN MARINE MANAGED AREAS OF CALIFORNIA, OREGON AND WASHINGTON

Fran Recht, Pacific States Marine Fisheries Commission
fran_recht@psmfc.org, 541-765-2229

There are hundreds of areas, known generally as "marine managed areas" (MMA)[1], in the marine and coastal environment that have been designated for a variety of reasons. Some areas, for example, protect special habitats or certain bird or fish or mammal species, while others provide public park land or research opportunities, while still others restrict navigational access for safety, security, or other purposes. The following tables provide information on the effects of an area's designation on fishing activities. A GIS layer that maps these areas is being assembled by Allison Bailey at TerraLogic GIS and will be made available on the Pacific Fishery Management Council and Pacific States Marine Fisheries Commission's websites when completed.

The table relates only to areas of marine or tidal influence and not to fresh water, riverine, or lake areas. It is broken down into three sections—areas established by federal agencies, areas established by the Pacific Fishery Management Council, and areas established by state, local, or private entities. This table does not yet reflect tribal fishing rules or the gear or area restrictions implemented by Washington treaty tribes. The columns include the site's name, location, year established, and provide information on the fishing regulations that are in place and what gear types can be used. There is a place-holder column to reflect whether kelp harvest is regulated, but most of it has not yet been completed. It is important to recognize that the fishing regulations noted in this table are only those specific regulations, if any, related to that site. There are sometimes regulations that apply to this site and surrounding waters that are not specific to the designation of this site. Those non-MMA-specific fishing restrictions **are not** reflected in this table, but can be applied as a filter when doing GIS-based analysis, a tool ideally suited for this task.

For example though this table might indicate that trawling is not specifically restricted in an MMA, other existing regulations might have already prohibited or restricted trawling more generally in the surrounding waters. Before running an analysis on information in this table, e.g. to find out how much area doesn't allow fishing with trawl gear, the GIS analyst would first apply a filter to the data in this table. The filter would be a rule of the type that says: if the state is California and the protected area is within three miles of shore (state waters) and is outside of an area where trawling s allowed, ignore Y (yes's) in the trawl gear column. That is, before an analysis of the data would be run, the filter would "correct" the table to reflect the more general fisheries rules that apply to that same geographic area. Information on those more general rules is presented below.

It should also be noted that each entry in the table is not a unique marine managed area. Some sites required multiple table entries to capture the details about sport and commercial fishing limitations, or regulations that are implemented by depth or federal or state authority or to capture seasonal changes.

For the columns related to whether certain gears are allowed, some other rules have been applied:

1. The notation 'not applicable' is used where the protected area is high tide and above on offshore rocks or non-aquatic uplands.
2. Where the protected area is high tide and above in estuarine, tidal, or stream environments, either Y (Yes) or N (No) is applied to indicate whether fishing can occur in these areas or not.
3. Areas that have no subtidal area can be assumed to have "No" commercial fishing trawl gear or bottomfish trawl gear (other gears e.g. hook and line and pots may possibly occur if there are estuarine areas or streams associated with the protected area).
4. If fishing is allowed at any time of year the notation is Y (yes). Any seasonal restrictions are explained in the column that spells out the fishing regulations that apply.
5. If there are year round restrictions on fishing the notation is N. If restrictions are only seasonal, the notation is Y.

[1] NOAA's Marine Protected Area center (www.mpa.gov) is proposing a definition of MMA that will be published in the Federal Register for public comment in 2005. This proposed definition results in a more restricted list of areas as it would include only sites established for a conservation purpose and having the same set of geographical boundaries for at least 2 consecutive years.

6. If any species is allowed to be fished with a certain gear (e.g. sanddabs), even if all other fishing is closed, the notation is Y.
7. A prohibition on public access or navigation is treated as if it were a fishing restriction and fishing gears would be given a N designation if the prohibition was year round, Y is the prohibition was seasonal.
8. Blank spaces or spaces with an 'unknown' notation indicate areas where information is not complete or was uncertain
9. Sometimes to provide further clarity to the regulations and the gear chart, one area was broken down into depth ranges or fisheries (e.g. inside 20 fathoms or outside, recreational restrictions versus commercial restrictions). These subsets are not officially designated as such by regulatory agencies.

This table is in draft form and corrections and comments are welcome and encouraged.

GENERAL INFORMATION ABOUT FISHING RULES THAT APPLY
The following information is provided to help provide an overview of other regulations that apply and allow the construction of filtering rules to further refine the gear use chart:

Trawl fishing on the continental shelf and shoreward of the Rockfish Conservation Areas. The Pacific Fishery Management Council implemented small footrope requirements January 4, 2000 (65 FR 221). These rules limit most groundfish trawl fishing on the continental shelf to those trawl nets with small footropes (equal to or less than 8" in diameter, including any rollers or rockhopper gear or midwater gear). Small footrope requirements also apply shoreward of the rockfish conservation areas. This small footrope requirement was implemented to prevent access to overfished groundfish species. From initial studies, small footropes have been effective at discouraging fishermen from accessing most rocky habitat. These small footrope rules do not reply to the spot prawn fishery. Small footrope trawl gear is defined in 50 CFR 660.302 and 660.322(b),

Information on Oregon State Regulations regarding commercial fishing in coastal state waters
Small footrope regulations (less than 8 inches) for most rockfish fisheries are incorporated into Oregon statute (OR 635.004.0018). This means that, for the most part, groundfish trawling is not often occurring in areas with rocky relief habitat.

A "gentleman's agreement" exists between Oregon trawlers and ODFW that restricts trawling in inshore waters except for traditional flatfish grounds. This agreement is generally understood to affect waters from 15-20 fathoms up to 100 fathoms in depth and has fishermen sticking to traditional sandy bottom areas and keeping out of rocky areas and was part of work to deal with black rockfish management issues (personal communication, Mark Saelens, ODFW, 2004).

Information on Washington State Regulations regarding commercial fishing in coastal state waters.
Beginning in 1996, regulations eliminated directed harvest of groundfish with hook and line or pot gear.

Trawling in Puget Sound is allowed only with nets having no roller gear and a foot rope diameter of less than five inches (which allows for the harvest of flatfish, e.g. starry flounder, sand sole), but prevents the net from being deployed in rocky areas. (2001)

Otter and beam trawl prohibited in state coastal waters (2001)

Trawl gear is prohibited gear for sea cucumber harvest

Spot prawn trawl fishery banned after 2002

Puget Sound pink shrimp fishery is beam trawl only .

<u>Information on California State Regulations regarding commercial fishing</u>

<u>Gillnet restrictions:</u> prohibit the take of rockfish within 3 miles of shore

<u>Setnets:</u> prohibited north of Point Reyes

<u>Trawl nets:</u> prohibited in state waters or within 3 miles of the mainland shore of districts 6,7,10, 17, 18, and 118.5, except

- Trawling for pink shrimp (Pandalus jordani) or prawns is allowed in CDFG districts 6,7,10,17,18, and 19 outside of 3 nm from mainland shore, offshore islands and the boundary line of District 19A except that trawling is allowed outside 2 nm from the nearest point of land on the mainland shore in an area extending due west from False Cape and a line extending due west from Pigeon Point.
- midwater trawling is allowed within one nautical mile of shore between Point Sur and Yankee Point.
- In the area between Point Sur and Yankee Point, trawling (except for midwater trawling, see above) is allowed outside of one nautical mile of shore.
- Trawling for CA halibut is allowed on specified southern CA halibut fishing grounds
- Trawling is allowed with trawl and Chinese shrimp nets inside of the Golden Gate Bridge for shrimp, oriental gobies, longjaw mudsuckers, plainfin midshipmen and staghorn sculpin
- The use of trawl nets to take spot prawns closed as of Feb 18, 2003
- Trawling for golden and ridgeback prawns permitted only in waters deeper than 25 fathoms and not closer than three nm from the nearest point of land on the mainland shore and from all offshore islands. No trawling in the cowcod closure area for these species. There are 5 trawl zones for these prawns (see Section 120.3 of Title 14, CCR
- Small footrope regulation for most rock fish fisheries incorporated into CA code (Cal Code Regs 8830).
- New rules further regulating bottom trawling in California state waters were passed September 23, 2004 through Senate Bill 1459. These rules further regulate fishing for California halibut, sea cucumbers, pink shrimp, ridge-back, spot and golden prawns. Provisions will be phased in beginning April 2006.

Regulatory Agency Abbreviations Used in the Table:

AFB	Air Force Base
CDFG	California Dept. of Fish and Game
CDPR	California Dept. of Parks and Recreation
DOI-NWR	Dept. of Interior, U.S. Fish and Wildlife Service
DOI-NPS	Dept. of Interior, National Parks Service
EPA	Environmental Protection Agency
NOAA-NMS	Dept. of Commerce, National Oceanic and Atmospheric Administration, National Marine Sanctuary Program
NOAA-NMFS	Dept. of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service
NOAA-NERR	Dept. of Commerce, National Oceanic and Atmospheric Administration, National Estuarine Research Reserve
ODFW	Oregon Dept. of Fish and Wildlife
MMS	Minerals Management Service
PFMC	Pacific Fishery Management Council
RWQCB	Regional Water Quality Control Boards
SLC	California State Lands Commission
WDFW	Washington Dept. of Fish and Wildlife
WDNR	Washington Dept. of Natural Resources
WSP	Washington State Parks
USFS-	U.S. Forest Service

FISHING REGULATIONS IN MARINE MANAGED AREAS OF CALIFORNIA, OREGON, AND WASHINGTON

Fran Recht, Pacific States Marine Fisheries Commission, 541-765-2229, fran_recht@psfmc.org

Appendix A

This document provides information on fishing rules that relate specifically to the special area designation (and not to fishing restrictions that might apply more generally to the surrounding area. It is divided into three sections. Section 1 relates to federally designated marine protected areas. Section 2 relates to areas designated by the Pacific Fishery Management Council and State Fisheries Agencies and Section 3 relates to state and locally designated areas. This document should be accompanied by a text file entitled Background Information: Fishing Regulations in Marine Managed Areas of California, Oregon and Washington, PSMFC, December 2004. This file provides background information about assumptions made in filling out this table and about the general fishing regulations that may apply. This document is also meant to be used with an accompanying GIS layer prepared by TerraLogic GIS, Inc. and available from PSMFC.

Note: Regulations may change over time. These represent current regulations as of September 2004. This document provides summarized information only and is not complete or official. Official fishing regulations are published in the federal register and in state rules. Contact National Marine Fisheries Service or your state agencies for information.

Section 1. Federally Designated Marine Managed Areas

SITE_ID	FULLNAME	AGENCY	YEAR ESTABLISHED	STATE	GIS layer updated?	Is this area closed to all fishing by regulations specific to the site?	Fishing Regulations specific to the site's designation	OTHER FISHING RELATED NOTES (R = recreational fishing, C = commercial fishing)	KELP or seaweed harvest restricted by rules specific to site?	OTHER INFORMATION	Is TRAWL gear allowed? (bottom, mid water, shrimp, beam trawls)	Are other NETS allowed? (seine, gillnet, salmon reefnet, demersal seine)	Is DREDGE gear allowed?	Is commercial POT gear allowed?	Is commercial HOOK & LINE gear allowed?	Is OTHER commercial fishing gear allowed?	Is recreational HOOK & LINE gear allowed?	Is recreational POT gear allowed?	Are OTHER recrea-tional fishing gears allowed?	Is Groundfish Bottom Trawl gear allowed?	Is Groundfish Longline gear allowed?	Is Groundfish pot gear allowed?	Is Groundfish mid-water TRAWL gear allowed?	Is recrea-tional Groundfish gear allowed?
NWR99	San Diego National Wildlife Refuge	DOI - USFWS	1996	CA	yes	Yes	fishing not allowed on refuge			S.San Diego Bay NWR contains mudflat and subtidal habitat 10-12 feet averge depth	N	N	N	N	N	N	N	N	N	N	N	N	N	N
NWR37	Don Edwards San Francisco Bay National Wildlife Refuge	DOI-USFWS	1972	CA	yes	No	sportfishing allowed, no commercial fishing				N	N	N	N	N	N	Y	Y	Y	N	N	N	N	Y
NWR101	San Pablo Bay National Wildlife Refuge	DOI-USFWS	1974	CA	yes	No	sportfishing allowed, no commercial fishing				N	N	N	N	N	N	Y	Y	Y	N	N	N	N	Y
NWR54	Humboldt Bay National Wildlife Refuge	DOI-USFWS	1973	CA	yes	No	sportfishing allowed, no commercial fishing				N	N	N	N	N	N	Y	Y	Y	N	N	N	N	Y
NWR141	Guadalupe-Nipomo Dunes National Wildlife Refuge	DOI-USFWS	2000	CA	yes	Yes	fishing not allowed on refuge	refuge is mean high tide and above		refuge is beach and dune area; no estuary. Approximately 3000 acres in size	not applicable	not applicable	not applicable	not applicable	not applicable	not applicable	not applicable	not applicable	not applicable	not applicable	not applicable	not applicable	not applicable	not applicable
NWR147	Lewis and Clark National Wildlife Refuge	DOI-USFWS	1972	OR/WA	yes	No	sportfishing allowed, no commercial fishing				N	N	N	N	N	N	Y	Y	Y	N	N	N	N	Y
NWR76	Nestucca Bay National Wildlife Refuge	DOI-USFWS	1991	OR	yes	Yes	fishing not allowed on refuge				N	N	N	N	N	N	N	N	N	N	N	N	N	N
NWR107	Siletz Bay National Wildlife Refuge	DOI-USFWS	1991	OR	yes	Yes	fishing not allowed on refuge				N	N	N	N	N	N	N	N	N	N	N	N	N	N
NWR11	Bandon Marsh National Wildlife Refuge	DOI-USFWS	1983	OR	yes	No	sportfishing allowed, no commercial fishing	intertidal			N	N	N	N	N	N	Y	Y	Y	N	N	N	N	Y
NWR155	Nisqually National Wildlife Refuge	DOI-USFWS	1974	WA	yes	No	sportfishing allowed, no commercial fishing				N	N	N	N	N	N	Y	Y	Y	N	N	N	N	Y
NWR124	Willapa National Wildlife Refuge	DOI-USFWS	1936	WA	yes	No	sportfishing allowed, no commercial fishing				N	N	N	N	N	N	Y	Y	Y	N	N	N	N	Y
NWR46	Grays Harbor National Wildlife Refuge	DOI-USFWS	1990	WA	yes	Yes	fishing not allowed on refuge				N	N	N	N	N	N	N	N	N	N	N	N	N	N
NWR38	Dungeness National Wildlife Refuge	DOI-USFWS	1915	WA	yes	No	recreational fishing only; restricted in four marine zones by zone and time of year. Treaty rights fisheries also occur.	fishing prohibited in winter to protect nesting birds			N	N	N	N	N	N	Y	Y	Y	N	N	N	N	Y
NWR115	Tijuana Slough National Wildlife Refuge	DOI-USFWS	1980	CA	yes	Yes	fishing not allowed on refuge			site is a coastal salt marsh.Ntl Estuarine Research Reserve overlay; also state park overlay	N	N	N	N	N	N	N	N	N	N	N	N	N	N
NWR100	San Juan Islands National Wildlife Refuge	DOI-USFWS	1960	WA	yes	not applicable	No public access on rocks	refuge is mean high tide and above on 83 rocks, reefs, and islands. No public access except Tern Island and Matia Island open to public. Have worked with San Juan Marine Resources Committee to establish voluntary fishing closure areas around some islands in subtidal zone			not applicable	not applicable	not applicable	not applicable	not applicable	not applicable	not applicable	not applicable	not applicable	not applicable	not applicable	not applicable	not applicable	not applicable
NWR103	Seal Beach National Wildlife Refuge	DOI-USFWS	1974	CA	yes	Yes	fishing not allowed on refuge	public use severely restricted. This 1000 acre coastal salt marsh site is owned by the Navy; this area is what is left of Annaheim Bay.			N	N	N	N	N	N	N	N	N	N	N	N	N	N
NWR156	Oregon Islands National Wildlife Refuge	DOI-USFWS	1935	OR	yes	not applicable	No public access on rocks	refuge is mean high tide and above		1853 rocks and islands	not applicable	not applicable	not applicable	not applicable	not applicable	not applicable	not applicable	not applicable	not applicable	not applicable	not applicable	not applicable	not applicable	not applicable
NWR160	Salinas River National Wildlife Refuge	DOI-USFWS	1973	CA	yes	No	sportfishing allowed, no commercial fishing	mostly upland, S managed by State Lands Commission manages to mean high tide			N	N	N	N	N	N	Y	Y	Y	N	N	N	N	Y
NWR149	Marin Islands National Wildlife Refuge	DOI-USFWS	1992	CA	yes	not applicable	No public access on rocks	refuge is mean high tide and above			not applicable	not applicable	not applicable	not applicable	not applicable	not applicable	not applicable	not applicable	not applicable	not applicable	not applicable	not applicable	not applicable	not applicable
NWR93	Protection Island National Wildlife Refuge (WITHIN 200 yards of shore)	DOI-USFWS	1982	WA	yes	Yes	fishing is restricted 200 yards from shore (NWR leases land from WA DNR) except that some treaty rights fisheries occur. No public access on rocks	refuge is mean high tide and above	vessels must stay 200 yards from island shore		N	N	N	N	N	N	N	N	N	N	N	N	N	N
NWR164	Sweetwater Marsh National Wildlife Refuge	DOI-USFWS	1988	CA	yes	Yes	fishing not allowed on refuge				N	N	N	N	N	N	N	N	N	N	N	N	N	N
NWR159	Quillayute Needles National Wildlife Refuge	DOI-USFWS	1907	WA	yes	not applicable	No public access on rocks	refuge is mean high tide and above		outer coast refuge. In total, the Quillayute Needles, Copalis and Flattery NWR consists of 600-800 rocks, reefs and islands.	not applicable	not applicable	not applicable	not applicable	not applicable	not applicable	not applicable	not applicable	not applicable	not applicable	not applicable	not applicable	not applicable	not applicable
NWR167	Three Arch Rocks National Wildlife Refuge	DOI-USFWS	1907	OR	yes	not applicable	No public access on rocks, Oregon State Marine Board closes area to boats 500 feet around the main rocks May 1-Sept 15th	refuge is mean high tide and above	vessels must stay 500 yards from main rocks May 1- Sept 15	9 rock islands, 15 acres total	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
NWR131	Cape Meares National Wildlife Refuge	DOI-USFWS	1938	OR	yes	not applicable	rocky headland	refuge is mean high tide and above		headland, old growth	not applicable	not applicable	not applicable	not applicable	not applicable	not applicable	not applicable	not applicable	not applicable	not applicable	not applicable	not applicable	not applicable	not applicable
NWR138	Flattery Rocks National Wildlife Refuge	DOI-USFWS	1907	WA	yes	not applicable	No public access on rocks	refuge is mean high tide and above.		outer coast refuge. In total, the Quillayute Needles, Copalis and Flattery NWR consists of 600-800 rocks, reefs and islands.	not applicable	not applicable	not applicable	not applicable	not applicable	not applicable	not applicable	not applicable	not applicable	not applicable	not applicable	not applicable	not applicable	not applicable
NWR31	Copalis National Wildlife Refuge	DOI-USFWS	1907	WA	yes	not applicable	No public access on rocks	refuge is mean high tide and above		outer coast refuge. In total, the Quillayute Needles, Copalis and Flattery NWR consists of 600-800 rocks, reefs and islands.	not applicable	not applicable	not applicable	not applicable	not applicable	not applicable	not applicable	not applicable	not applicable	not applicable	not applicable	not applicable	not applicable	not applicable
NPS27	Olympic National Park	DOI-USFWS	1909	WA	yes	No	open to recreational fishing, some gear regulations (e.g. number of hooks, spinners etc.)	Park boundary is at lower low water			N	N	N	N	N	N	Y			N	N	N	N	
NWR132	Castle Rock National Wildlife Refuge	DOI-USFWS	1980	CA	yes	not applicable	No public access on rocks	refuge is mean high tide and above			not applicable	not applicable	not applicable	not applicable	not applicable	not applicable	not applicable	not applicable	not applicable	not applicable	not applicable	not applicable	not applicable	not applicable
	Antioch Dune National Wildlife Refuge	DOI-USFWS		CA			fishing not allowed on refuge	tidal area in Delta			N	N	N	N	N	N	N	N	N	N	N	N	N	N
NWR137	Farallon National Wildlife Refuge	DOI-USFWS	1909	CA	yes	not applicable	No public access on rocks	refuge is mean high tide and above			not applicable	not applicable	not applicable	not applicable	not applicable	not applicable	not applicable	not applicable	not applicable	not applicable	not applicable	not applicable	not applicable	not applicable
NPS33	San Juan Island National Historical Park	DOI - NPS	1966	WA	yes			no subtidal area			not applicable	not applicable	not applicable	not applicable	not applicable	not applicable	not applicable	not applicable	not applicable	not applicable	not applicable	not applicable	not applicable	not applicable

SITE_ID	FULLNAME	AGENCY	YEAR ESTABLISHED	STATE	GIS layer updated?	Is this area closed to all fishing by regulations specific to the site?	Fishing Regulations **specific to the site's designation**	OTHER FISHING RELATED NOTES (R = recreational fishing, C = commercial fishing)	KELP or seaweed harvest restricted by rules specific to site?	OTHER INFORMATION	Is TRAWL gear allowed? (bottom, mid water, shrimp, beam trawls)	Are other NETS allowed? (seine, gillnet, salmon reefnet, demersal seine)	Is DREDGE gear allowed?	Is commer-cial POT gear allowed?	Is commer-cial HOOK & LINE gear allowed?	Is OTHER commer-cial fishing gear allowed?	Is recreational HOOK & LINE gear allowed?	Is recrea-tional POT gear allowed?	Are OTHER recrea-tional fishing gears allowed?		Is Groundfish Bottom Trawl gear allowed?	Is Groundfish Longline gear allowed?	Is Groundfish pot gear allowed?	Is Groundfish mid-water TRAWL gear allowed?	Is recrea-tional Groundfish gear allowed?
NPS31	Redwood National Park	DOI - NPS, CDFG	1968	CA	yes	No	To 1000 feet offshore, finfish and certain invertebrates may be taken	abalone (R,C); crabs (R,C); lobster (R,C); ghost shrimp (R,C); seaurchins (R,C); worms (R, C); chiones (R); clams (R); cockles (R);rock scallops (R); native oysters (R); jackknife clams (C); squid (C);	Yes. Marine aquatic plants may not be cut or harvested		Y	Y	Y	Y	Y	Y	Y	Y	Y		Y	Y	Y	Y	Y
NPS19	Golden Gate National Recreation Area	DOI - NPS, CDFG	1972	CA	yes	No	To 1000 feet offshore, finfish and certain invertebrates may be taken	abalone (R,C); crabs (R,C); lobster (R,C); ghost shrimp (R,C); seaurchins (R,C); worms (R, C); chiones (R); clams (R); cockles (R);rock scallops (R); native oysters (R); jackknife clams (C); squid (C);	Yes. Marine aquatic plants may not be cut or harvested		Y	Y	Y	Y	Y	Y	Y	Y	Y		Y	Y	Y	Y	Y
NPS30	Point Reyes National Seashore	DOI - NPS, CDFG	1972	CA	yes	No	To 1000 feet offshore, finfish and certain invertebrates may be taken	abalone (R,C); crabs (R,C); lobster (R,C); ghost shrimp (R,C); seaurchins (R,C); worms (R, C); chiones (R); clams (R); cockles (R);rock scallops (R); native oysters (R); jackknife clams (C); squid (C);			Y	Y	Y	Y	Y	Y	Y	Y	Y		Y	Y	Y	Y	Y
NPS7	Cabrillo National Monumen	DOI - NPS, CDFG		CA	yes	No	Recreational and commercial fishing are allowed; bu no invertebrates may be taken and finfish may only be taken by hook and line				N	N	N	N	Y	N	Y	N	Y		N	N	N	N	Y
NMS1	Channel Islands National Marine Sanctuary (CINMS) (FEDERAL WATERS)	NOAA - NMS	1980	CA	yes	No	Recreational and commercial fishing allowed in federal waters	Offshore boundary 6 nm distance; coastline length approx 150 mi.	no kelp harvest restrictions		Y	Y	Y	Y	Y	Y	Y	Y	Y		Y	Y	Y	Y	Y
NMS11	Monterey Bay National Marine Sanctuary	NOAA - NMS	1992	CA		No	no restrictions on recreational and commercial fishing			5300 square mile marine protected area	Y	Y	Y	Y	Y	Y	Y	Y	Y		Y	Y	Y	Y	Y
NMS13	Olympic Coast National Marine Sanctuary	NOAA - NMS	1994	WA		No	no restrictions on recreational and commercial fishing				Y	Y	Y	Y	Y	Y	Y	Y	Y		Y	Y	Y	Y	Y
NMS8	Gulf of the Farallones National Marine Sanctuary (OUTSIDE OF 10 FATHOMS DEPTH CONTOUR)	NOAA - NMS	1981	CA	yes	No	recreational and commercial fishing are allowed.	Area 32.2 square nm, Depth range 0-360 feet (0-60 fathoms)			Y	Y	Y	Y	Y	Y	Y	Y	Y		Y	Y	Y	Y	Y
NMS8	Gulf of the Farallones National Marine Sanctuary (INSIDE OF 10 FATHOM DEPTH CONTOUR)	NOAA - NMS	1981	CA	yes	No	recreational and commercial fishing are allowed except that commercial fishing for all groundfish is prohibited between the shoreline and the 10 fathom (18 m) depth contour around the Farrallon islands and in this same area recreational fishing for certain species is prohibited (rockfish, lingcod, cabezon, greenlings of genus Hexacrammos, CA scorpionfish CA sheephead and ocean whitefish)	Area 32.2 square nm, Depth range 0-360 feet (0-60 fathoms)			Y	Y	Y	Y	Y	Y	Y	Y	Y		N	N	N	N	Y
NMS2	Cordell Bank National Marine Sanctuary (OUTSIDE 5 nm radius around special point)	NOAA - NMS	1989	CA	yes	No	recreational and commercial fishing are allowed.	Benthic invertebrates located on Cordell bank or within 50 fathom line may not be taken. In April 2004, Cordell Banks located inside groundfish Trawl and Non trawl RCAs. Therefore, prohibited to fish for groundfish except sanddabs with gear restrictions.	Benthic algae located on Cordell bank or within 50 fathom line may not be taken		Y	Y	Y	Y	Y	Y	Y	Y	Y		Y	Y	Y	Y	Y
NMS2	Cordell Bank National Marine Sanctuary (INSIDE 5 nm radius of special point)	NOAA - NMS	1989	CA	yes	No	recreational and commercial fishing are allowed except that recreational fishing for rockfish, lingcod, cabezon, CA scorpionfish, kelp greenlings,greenlings of the genus Hexagrammos, CA sheephead and ocean whitefish are prohibited within a 5 nm radius around a point located at 38 degrees 02 ' N lat and 123 degrees 25'W. long	Benthic invertebrates located on Cordell bank or within 50 fathom line may not be taken. In April 2004, Cordell Banks located inside groundfish Trawl and Non trawl RCAs. Therefore, prohibited to fish for groundfish except sanddabs with gear restrictions.	Benthic algae located on Cordell bank or within 50 fathom line may not be taken		Y	Y	Y	Y	Y	Y	Y	Y	Y		Y	Y	Y	Y	Y
NMF35	Pacific Whiting Columbia River Salmon Conservation Zone	NOAA - NMFS		WA/OR	yes	No	Closed to Pacific whiting fishery. Pacific whiting may not be taken or retained			area stretches approximately 6 nm due west from N. Head, runs south along the Columbia River Buoy and then east along the Red Buoy line to tip of the South Jetty.	Y	Y	Y	Y	Y	Y	Y	Y	Y		Y	Y	Y	N	Y
NER18	Padilla Bay National Estuarine Research Reserve	NOAA/STATE - NERR	1980	WA	yes	No				11,000 acres. Subtidal, intertidal. Contains seagrass meadows, tidal flats and sloughs, salt marshes, upland forests and meadows. Public access restricted and discouraged in sensitive marsh areas.															
NER21	South Slough National Estuarine Research Reserve	NOAA/STATE - NERR	1974	OR	yes	No	No fishing restrictions, except that commercial oyste culture limited to 100 acres.	Recreational clamming and bait gathering allowed.			Y	Y	Y	Y	Y	Y	Y	Y	Y		Y	Y	Y	Y	Y
NER22	Tijuana River National Estuarine Research Reserve	NOAA/STATE - NERR	1982	CA	yes	Yes	recreational and commercial fishing prohibited				N	N	N	N	N	N	N	N	N		N	N	N	N	N
NER6	Elkhorn Slough National Estuarine Research Reserve	NOAA/STATE - NERR	1979	CA	yes																				
	Pt. Reyes Headlands National Research Natural Area	DOI-NPS, CDFG	1972	CA																					
	San Francisco Maritime National Historical Park	DOI-NPS	1988	CA																					
	Santa Monica Mountains National Recreational Area	DOI-NPS, CDPR	1978	CA																					
	Ebey's Landing National Historical Reserve	DOI-NPS, WPRC	1978	WA																					
	Channel Islands Man and the Biosphere (MAB) Reserve	NOAA, NPS	1976	CA		No	recreational and commercial fishing are allowed				Y	Y	Y	Y	Y	Y	Y	Y	Y		Y	Y	Y	Y	Y
	Central California Coast MAB Reserve	NOAA, NPS	1988	CA		No	recreational and commercial fishing are allowed				Y	Y	Y	Y	Y	Y	Y	Y	Y		Y	Y	Y	Y	Y
	Cascade Head MAB Reserve	USFS	1976	OR		No	no fisheries-specific regulations				Y	Y	Y	Y	Y	Y	Y	Y	Y		Y	Y	Y	Y	Y
	Olympic MAB Reserve	NPS	1976	WA		No	Recreational fishing is allowed; national park boundary is at lower low water.				N	N	N	N	N	N	Y	Y	Y		N	N	N	N	Y
	Undersea Cables (20 locations, see Didier, 1998)					No	no fisheries-specific regulations, but civic penalites can be levied by companies against those who break or injure cable through culpable negligence. Bottom fishing gear is advised to be kept a distance of 1 nm from both sides of the charted location of all submarine cables.	subtidal, intertidal.		recommendations about avoiding damaging cables may result in bottom gear use limitations	Y	Y	Y	Y	Y	Y	Y	Y	Y		Y	Y	Y	Y	Y
	Offshore Drilling Platforms (37 locations mapped by Didier, 1998)	MMS				No	no-fisheries specific regulations, but some structures are protected by regulations that restrict access to the general vicinity by large vessels or by vessels in tow.	See 33 CFR 147 for regulations		regulations restricting access to large vessles and vessels in tow may result in some gear use limitations	Y	Y	Y	Y	Y	Y	Y	Y	Y		Y	Y	Y	Y	Y

SITE_ID	FULLNAME	AGENCY	YEAR ESTABLISHED	STATE	GIS layer updated?	Is this area closed to all fishing by regulations specific to the site?	Fishing Regulations **specific to the site's designation**	OTHER FISHING RELATED NOTES (R = recreational fishing, C = commercial fishing)	KELP or seaweed harvest restricted by rules specific to site?	OTHER INFORMATION	Is TRAWL gear allowed? (bottom, mid-water, shrimp, beam trawls)	Are other NETS allowed? (seine, gillnet, salmon reefnet, demersal seine)	Is DREDGE gear allowed?	Is commercial POT gear allowed?	Is commercial HOOK & LINE gear allowed?	Is OTHER commercial fishing gear allowed?	Is recreational HOOK & LINE gear allowed?	Is recreational POT gear allowed?	Are OTHER recrea-tional fishing gears allowed?		Is Groundfish Bottom Trawl gear allowed?	Is Groundfish Longline gear allowed?	Is Groundfish pot gear allowed?	Is Groundfish mid-water TRAWL gear allowed?	Is recrea-tional Groundfish gear allowed?
	Weather and Scientific Buoys (27 locations mapped by Didier, 1998)	NOAA				No	no fisheries specific regulations, though vessels are advised to give buoys a wide berth to avoid entangling with the buoy's mooring or other equipment. NOAA recommends that vessels trailing gear allow 500 yards clearance and that all others allow at least 20 yard clearance.	subtidal		recommendations about avoiding buoys cables may result in some gear use limitations	Y	Y	Y	Y	Y	Y	Y	Y	Y		Y	Y	Y	Y	Y
	Regulated Navigation Areas (22 areas mapped and regulations described by Didier, 1998)	US Coast Guard				No	navigation restrictions; no fisheries-specific regulations	See 33 CFR 165 for regulations.		navigation restricted in the vicinity of military reservations, or in areas with high levels of vessel traffic	Y	Y	Y	Y	Y	Y	Y	Y	Y		Y	Y	Y	Y	Y
	Danger Zones and Restricted Areas (65 areas mapped and described by Didier, 1998). Didier did not map 15 additional sites in inner harbors of San Diego Bay, Anaheim Bay, San Francisco Bay, and San Pablo Bay.	U.S. Dept of Defense, Corps of Engineers				No	navigation restrictions of either a temporary or permanent basis; no fisheries-specific regulations	See 33 CFR 334 for regulations.		Waters in the vicinity of military installations may be closed for reasons of station security or when military operations are underway. Didier (1998)	Y	Y	Y	Y	Y	Y	Y	Y	Y		Y	Y	Y	Y	Y
Section 2. Fishing Regulated Areas Established by the Pacific Fishery Management Council and State Fishing Agencies																									
	Cowcod Conservation Areas (CCAs)- RECREATIONAL FISHING (OUTSIDE OF 20 FATHOMS)	PFMC	January 2001 to present	CA		No	recreational fishing for all groundfish is prohibited in federal waters except that fishing for sanddabs is allowed with some gear and other location based restrictions	Changes in boundaries and species restrictions over time.	N		Y	Y	Y	Y	Y	Y	Y	Y	Y		Y	Y	Y	Y	Y
	Cowcod Conservation Areas (CCAs)- RECREATIONAL FISHING (SHOREWARD OF 20 FATHOMS)	PFMC	January 2001 to present	CA		No	recreational fishing for groundfish is allowed March 1 - December 31, 2004, shoreward of the 20 fathom (37m) contour for minor nearshore rockfish (except for cowcod, canary, and yelloweye), cabezon, lingcod, CA scorpionfish, sanddabs, kelp greenling, and greenlings of the Genus Hexogrammas.	Changes in boundaries, species restrictions, ans seasons over time.	N		Y	Y	Y	Y	Y	Y	Y	Y	Y		Y	Y	Y	Y	Y
	Cowcod Conservation Areas (CCAs) - COMMERCIAL FISHING (OUTSIDE OF 20 FATHOMS)	PFMC	January 2001 to present	CA		No	commercial fishing for groundfish prohibited year round. Trawling for golden and ridgeback prawns prohibited	changes in boundaries over time.	N		N	Y	Y	Y	Y	Y	Y	Y	Y		N	N	N	N	Y
	Cowcod Conservation Areas (CCAs)- COMMERCIAL FISHING (INSIDE OF 20 FATHOMS)	PFMC	January 2001 to present	CA		No	commercial fishing for groundfish prohibited year round except that rockfish and lingcod fishing is permitted shoreward of 20 fathoms (37 m) depth contour.	changes in boundaries over time.	N		N	Y	Y	Y	Y	Y	Y	Y	Y		N	N	N	N	Y
	Groundfish Area Closure (SHOREWARD OF 20 FATHOMS)	PFMC	July 2002 to Sept. 2002	WA, OR, CA		No	Large footrope bottom trawl groundfish fishing closed on July 1 north of 40°10N. latitude. S. of 40°10' N. latitude, as of July 1, limited entry trawl gear and exempted trawl gear prohibited for some species, exempted trawl gear may not retain groundfish.	South of 40°10 N. lat, trawl for DTS complex (Dover sole, thornyheads, and sablefish), minor slope rockfish, flatfish, and grenadier permitted.	N		Y	Y	Y	Y	Y	Y	Y	Y	Y		Y	Y	Y	Y	Y
	Groundfish Area Closure (OUTSIDE OF 20 FATHOMS)	PFMC	Commercial- July 2002 to Sept. 2002; Recreational- May 2002 to Oct. 2002	WA, OR, CA		No	Large footrope bottom trawl groundfish fishing closed on July 1 north of 40°10N. latitude. S. of 40°10' N. latitude, as of July 1, limited entry trawl gear prohibited for some species, exempted trawl gear may not retain groundfish, and recreational fishing for rockfish and lingcod prohibited outside of 20 fathoms (May -Oct between 40°10N. lat. amd 34°27' N. lat; Jul-Oct south of 34°27 N. lat.), limited entry fixed gear groundfish fishing prohibited outside of 20 fathoms (except for sablefish, thornyheads, and slope rockfish)	South of 40°10 N. lat, trawl for DTS complex (Dover sole, thornyheads, and sablefish), minor slope rockfish, flatfish, and grenadier permitted.	N		Y	Y	Y	Y	Y	Y	Y	Y	Y		Y	Y	Y	Y	Y
	Darkblotched Rockfish Closure Area (DBCA)	PFMC	Sept 2002 to March 2003	WA, OR, CA		No	North of 40°10 N. lat., limited entry groundfish trawl fishing prohibited, except that fishing for Pacific whiting is allowed with mid-water trawl gear. In Sept 2002, all limited entry groundfish trawl fishing also prohibited shoreward of DBCA.		N		Y	Y	Y	Y	Y	Y	Y	Y	Y		N	Y	Y	Y	Y
	Yelloweye Rockfish Conservation Area (YRCA)	PFMC	January 2003 to present	WA		No	Recreational groundfish and halibut fishing prohibited. Voluntary closure for the limited entry fixed gear sablefish fleet and salmon trollers	changes in boundary over time	N		Y	Y	Y	Y	Y	Y	Y	Y	Y		Y	Y	Y	Y	N
	Rockfish Conservation Area (RCA)- RECREATIONAL groundfish fishery	PFMC, WDFW	Nov 2003 to present	WA		No	Nov. 21 - Dec. 31, 2003, recreational fishing for all groundfish prohibited from 3-200 nm.		N	RCA is generally defined by depth countours but specifically defined by lat/long coordinates that is gear/and or sector specific. Boundaries may vary seasonally	Y	Y	Y	Y	Y	Y	Y	Y	Y		Y	Y	Y	Y	Y
	Rockfish Conservation Area (RCA)- RECREATIONAL groundfish fishery	PFMC, ODFW	Nov 2003 to present	OR		No	In Oregon recreational fishing for groundfish prohibited seaward of a boundary line approximating the 27-fm depth contour from Nov. 21- Dec. 31, 2003. In Oregon recreational fishing for groundfish prohibited seaward of a boundary line approximating the 40-fm depth contour from June 1-September 30, 2004.	changes in boundaries and season over time	N	RCA is generally defined by depth countours but specifically defined by lat/long coordinates that is gear/and or sector specific. Boundaries may vary seasonally	Y	Y	Y	Y	Y	Y	Y	Y	Y		Y	Y	Y	Y	Y
	Rockfish Conservation Area (RCA)- RECREATIONAL groundfish fishery	PFMC, CDFG	Nov 2003 to present	CA, from 42° N. latitude and 40°10' N.		No	Retention of all federally managed groundfish species, except sanddabs, is prohibited in the recreational fishery seaward of California November 21 through December 31, 2003. For 2004, Recreational fishing for all groundfish, except sanddabs is prohibited seaward of a boundary line approximating the 30 fathom (55 m) depth contour along the mainland coast and along islands and offshore seamounts during May-Dec, 2004.	changes in boundaries and season over time	N	RCA is generally defined by depth countours but specifically defined by lat/long coordinates that is gear/and or sector specific. Generally, lines in state waters (equal to or less than 20 fm) are defined by the actual depth contour and not coordinates. Boundaries may vary seasonally.	Y	Y	Y	Y	Y	Y	Y	Y	Y		Y	Y	Y	Y	Y

SITE_ID	FULLNAME	AGENCY	YEAR ESTABLISHED	STATE	GIS layer updated?	Is this area closed to all fishing by regulations specific to the site?	Fishing Regulations **specific to the site's designation**	OTHER FISHING RELATED NOTES (R = recreational fishing, C = commercial fishing)	KELP or seaweed harvest restricted by rules specific to site?	OTHER INFORMATION	Is TRAWL gear allowed? (bottom, mid water, shrimp, beam trawls)	Are other NETS allowed? (seine, gillnet, salmon reefnet, demersal seine)	Is DREDGE gear allowed?	Is commercial POT gear allowed?	Is commercial HOOK & LINE gear allowed?	Is OTHER commercial fishing gear allowed?	Is recreational HOOK & LINE gear allowed?	Is recreational POT gear allowed?	Are OTHER recrea-tional fishing gears allowed?		Is Groundfish Bottom Trawl gear allowed?	Is Groundfish Longline gear allowed?	Is Groundfish pot gear allowed?	Is Groundfish mid-water TRAWL gear allowed?	Is recrea-tional Groundfish gear allowed?
	Rockfish Conservation Area (RCA)-RECREATIONAL groundfish fishery	PFMC, CDFG	January 2002 to present	CA, from 40°10' N. latitude and 34°27' N.		No	or 2002 between 40°10' N. lat. and 34°27' N. lat., recreational fishing for rockfish is closed from March through April, and from Nov through Dec. This area also closed to recreational rockfish fishing from May through Oct, except that fishing for rockfish is permitted inside the 20 fm (37 m) depth contour. For 2003 between 40°10' N. lat. and 34°27' N. lat., recreational fishing for all groundfish is prohibited seaward of the 20-fm (37-m) depth contour, except that recreational fishing for sanddabs is permitted seaward of the 20- fm (37-m) depth contour. Retention of all federally managed groundfish species, except sanddabs, is prohibited in the recreational fishery seaward of California November 21 through December 31, 2003. For 2004 between 40°10' N. lat. and 36° N. lat., Recreational fishing for all groundfish, except sanddabs is prohibited seaward of a boundary approximating the 30 fathom (55 m) depth contour along the mainland coast and along islands and offshore seamounts during Jan 1 through February 29~~and Sept. 30 through Dec 31~~and	changes in boundaries and season over time	N	RCA is generally defined by depth countours but specifically defined by lat/long coordinates that is gear/and or sector specific. Generally, lines in state waters (equal to or less than 20 fm) are defined by the actual depth contour and not coordinates. Boundaries may vary seasonally.	Y	Y	Y	Y	Y	Y	Y	Y	Y		Y	Y	Y	Y	Y
	Rockfish Conservation Area (RCA)-RECREATIONAL groundfish fishery	PFMC, CDFG	January 2002 to present	CA, south of 34°27' N		No	For 2002, recreational fishing for rockfish is closed from Jan through Feb and from Nov through Dec. This area is also closed to recreational rockfish fishing from July through Oct, except that fishing for rockfish is permitted inside the 20 fm (37 m) depth contour. For 2003, recreational fishing for all groundfish is prohibited seaward of a boundary line approximating the 30-fm (55-m) depth contour along the mainland coast and along islands and offshore seamounts, except that recreational fishing for sanddabs is permitted seaward of the 30-fm (55-m) depth contour. Retention of all federally managed groundfish species, except sanddabs, is prohibited i the recreational fishery seaward of California November 21 through December 31, 2003. For 2004, Recreational fishing for all groundfish, except sanddabs is prohibited seaward of a boundary approximating the 60 fathom (110 m) depth contour along the mainland coast and along islands and offshore seamounts during March 1 through Aug 31 and Nov through Dec, is prohibited seaward of a boundary line approximating 30 fm during Sep throu	changes in boundaries and season over time	N	RCA is generally defined by depth countours but specifically defined by lat/long coordinates that is gear/and or sector specific. Generally, lines in state waters (equal to or less than 20 fm) are defined by the actual depth contour and not coordinates. Boundaries may vary seasonally.	Y	Y	Y	Y	Y	Y	Y	Y	Y		Y	Y	Y	Y	Y
	Rockfish Conservation Area (RCA)-TRAWL Groundfish Fishery (limited entry and open access exempted trawl gear)	PFMC	Jan 2003 to present	WA,OR, CA		No	all trawling prohibited except that trawling for whiting (or widow or yellowtail rockfish, if allowed) using midwater gear and for pink shrimp trawling is allowed.	changes in boundaries, gear, and species restrictions over time. Jan 2003 - June 2004, small footrope or midwater gear is required shoreward of the RCA. July 1, 2004, Small footrope or midwater gear is required shoreward of the RCA north of 40°10' N. lat.; Small footrope gear is required shoreward of the RCA south of 40°10' N. lat.	N	RCA is generally defined by depth countours but specifically defined by lat/long coordinates that is gear/and or sector specific. Boundaries may vary seasonally	Y	Y	Y	Y	Y	Y	Y	Y	Y		N	Y	Y	Y	Y
	Rockfish Conservation Area (RCA)-NON-TRAWL Groundfish Fishery (limited entry fixed gear, open access non-trawl gears including longline and pots, gillnets)	PFMC	Jan 2003 to present	WA,OR, CA		No	fishing for groundfish is prohibited, except that fishing for sanddabs with gear restrictions is permitted; fishing for other species with this gear, e.g. salmon, ok	changes in boundaries and species restrictions over time	N	RCA is generally defined by depth countours but specifically defined by lat/long coordinates that is gear/and or sector specific. Boundaries may vary seasonally	Y	Y	Y	Y	Y	Y	Y	Y	Y		Y	N	N	Y	Y
	Section 3. State and Local Marine Managed Areas																								
Washington																									
	Yellow and Low Islands Marine Preserve	WDFW. (The Nature Conservancy owns uplands; serve as co-managers).	1990	WA	yes	No	Closed to recreational and commercial fishing for bottomfish and shellfish and all forage fish except for herring. Recreational fishing for salmon, trout, and other unclassified fish allowed; commercial fishing for salmon allowed but no other unclassified fish.		No	intertidal area: 1.5 acres; subtidal area: 185. acres (area calculated from map layers)	N	Y	N	N	Y	N	Y	N	Y		N	N	N	N	N
	Friday Harbor Marine Preserve	WDFW. (Uplands owned by U. of Washington Friday Harbor Lab).	1990	WA	yes	No	Closed to recreational and commercial fishing for bottomfish and shellfish and all forage fish except for herring. Recreational fishing for salmon, trout, and other unclassified fish allowed; commercial fishing for salmon allowed but no other unclassified fish.		No	intertidal area: 0.7 acres; subtidal area: 424. acres	N	Y	N	N	Y	N	Y	N	Y		N	N	N	N	N
	Shaw Island Marine Preserve	WDFW. (Uplands owned by U. of Washington Friday Harbor Lab; serve as co-managers).	1990	WA	yes	No	Closed to recreational and commercial fishing for bottomfish. Closed to all recreational and commercial shellfish harvesting except crabbing is allowed in Parks Bay. Closed to recreational and commercial harvesting of all forage fish except herring fishing is allowed. Recreational fishing for salmon, trout, and other unclassified fish allowed; commercial fishing for salmon allowed but no other unclassified fish.		No	intertidal area: 0.5 acres; subtidal area 453.3 acres (area calculated from map layers)	N	Y	N	Y	Y	N	Y	Y	Y		N	N	N	N	N

SITE_ID	FULLNAME	AGENCY	YEAR ESTABLISHED	STATE	GIS layer updated?	Is this area closed to all fishing by regulations specific to the site?	Fishing Regulations **specific to the site's designation**	OTHER FISHING RELATED NOTES (R = recreational fishing, C = commercial fishing)	KELP or seaweed harvest restricted by rules specific to site?	OTHER INFORMATION	Is TRAWL gear allowed? (bottom, mid water, shrimp, beam trawls)	Are other NETS allowed? (seine, gillnet, salmon reefnet, demersal seine)	Is DREDGE gear allowed?	Is commer-cial POT gear allowed?	Is commer-cial HOOK & LINE gear allowed?	Is OTHER commer-cial fishing gear allowed?	Is recreational HOOK & LINE gear allowed?	Is recrea-tional POT gear allowed?	Are OTHER recrea-tional fishing gears allowed?		Is Groundfish Bottom Trawl gear allowed?	Is Groundfish Longline gear allowed?	Is Groundfish pot gear allowed?	Is Groundfish mid-water TRAWL gear allowed?	Is recrea-tional Groundfish gear allowed?
	Argyle Lagoon Marine Preserve	WDFW. (Uplands owned by U. of Washington Friday Harbor Lab).	1990	WA	yes	No	Closed to recreational and commercial fishing for bottomfish and shellfish and all forage fish except for herring. Recreational fishing for salmon, trout, and other unclassified fish allowed; commercial fishing for salmon allowed but no other unclassified fish.		No	intertidal: 1.31 acres, subtidal 13.0 acres	N	Y	N	N	Y	N	Y	N	Y		N	N	N	N	N
	False Bay Marine Preserve	WDFW. (Tidelands owned by U. of Washington, Friday Harbor Lab).	1990	WA	yes	No	Closed to recreational and commercial fishing for bottomfish and shellfish and all forage fish except for herring. Recreational fishing for salmon, trout, and other unclassified fish allowed; commercial fishing for salmon allowed but no other unclassified fish.		No	Intertidal area: 226.2 acres, subtidal area: 80.5 acres	N	Y	N	N	Y	N	Y	N	Y		N	N	N	N	N
	Admiralty Head Marine Preserve- Marine Area 9	WDFW	2002	WA	yes	No	closed to all harvest except sea urchin and sea cucumber harvest is allowed.		No	Intertidal area: none; subtidal area: 88.4 acres	N	N	N	N	N	Y	N	N	N		N	N	N	N	N
	Keystone Harbor Conservation Area- Marine Area 9	WDFW. (State Park helps with patrol, signage).	2002	WA	yes	Yes	closed to all harvest		No	intertidal area: none; subtidal 11.4 acres	N	N	N	N	N	N	N	N	N		N	N	N	N	N
	Brackett's Landing Shoreline Sanctuary Conservation Area (formerly Edmonds Underwater Park)- Marine Area 9	WDFW, City of Edmonds	1970	WA	yes	Yes	closed to all harvest	tribal no fishing area	No	intertidal area: 25.9 acres; subtidal area: 33 acres	N	N	N	N	N	N	N	N	N		N	N	N	N	N
	Orchard Rocks Conservation Area- Marine Area 10	WSP, WDFW?	1998	WA	yes	Yes	closed to all harvest except closure does not affect privately owned fish in net pens and the harvest of clams, oysters and mussels by tideland owners and their families.		No	intertidal area: 2.0 acres; subtidal area 101.7 acres	N	N	N	N	N	N	N	N	N		N	N	N	N	N
	Waketickeh Creek Conservation Area- Marine Area 12	WDFW	2000	WA	yes	Yes	closed to all harvest except that tideland owners and their familes may still harvest clams, oysters, and mussels from their property		No	intertidal area: 0.3 acres; subtidal area: 146. acres	N	N	N	N	N	N	N	N	N		N	N	N	N	N
	Octopus Hole Conservation Area- Marine Area 12	WDFW	1998	WA	yes	Yes	closed to harvest year-round, except inside of 100 feet seaward of the high water mark		No	intertidal area: none; subtidal area: 27.1 acres	N	N	N	N	N	N	N	N	N		N	N	N	N	N
	Sund Rock Conservation Area- Marine Area 12	WDFW	1994	WA	yes	Yes	closed to all harvest except tideland owners and their families may still harvest clams, oysters and mussels from their property		No	intertidal area: none; subtidal area: 71.2 acres	N	N	N	N	N	N	N	N	N		N	N	N	N	N
	Saltar's Point Conservation Area- Marine Area 13	WDFW. (City of Steilacoom does on site management).	2000	WA	yes	Yes	city owned tidelands and water column above tidelands closed to all harvest		No	intertidal area: 3.9 acres; subtidal area: none	N	N	N	N	N	N	N	N	N		N	N	N	N	N
	Zee's Reef Marine Preserve Area 13	WDFW	2002	WA	yes	No	closed to all harvest except recreational fly fishing for salmon is allowed		No	intertidal area: none; subtidal area: 56.0 acres	N	N	N	N	N	N	Y	N	N		N	N	N	N	N
	Titlow Beach Marine Preserve- Marine Area 13	WDFW. (Cooperative project with City of Tacoma).	1994	WA	yes	No	closed to all harvest, except recreational salmon fishing using lures only is permitted from shore or non-motorized craft.		Yes	intertidal area: 14.8 acres; subtidal area: 26. acres	N	N	N	N	N	N	Y	N	N		N	N	N	N	N
	City of Des Moines Park Conservation Area- Marine Area 11	WDFW, City of Des Moines (does on site management)	1998	WA	yes	Yes	closed to all harvest	also a suspected tribal no-fishing area	No	intertidal area: 9.2 acres; subtidal area: none	N	N	N	N	N	N	N	N	N		N	N	N	N	N
	South 239th Street Park Conservation Area-Marine Area 11	WDFW, City of Des Moines (does on site management)	1998	WA	yes	Yes	closed to all harvest		No	intertidal area O.2 acres; subtidal area: none	N	N	N	N	N	N	N	N	N		N	N	N	N	N
	Colvos Passage Marine Preserve- Marine Area 11	WDFW	2000	WA	yes	No	closed to all harvest except recreational salmon trolling allowed		No	intertidal area: none; subtidal area 3.26 acres	N	N	N	N	N	N	Y	N	N		N	N	N	N	N
	Copalis Beach Razor Clam Reserve	WDFW		WA		No	permanently closed to razor clam harvest		No	1/4 mile section of coastal ocean beach	Y	Y	Y	Y	Y	Y	Y	Y	Y		Y	Y	Y	Y	Y
	Twin Harbors Reserve	WDFW		WA		No	permanently closed to razor clam harvest		No	1/4 mile section of coastal ocean beach	Y	Y	Y	Y	Y	Y	Y	Y	Y		Y	Y	Y	Y	Y
	Long Beach Reserve	WDFW		WA		No	permanently closed to razor clam harvest		No	1/4 mile section of coastal ocean beach	Y	Y	Y	Y	Y	Y	Y	Y	Y		Y	Y	Y	Y	Y
	Sea cucumber and urchin Exclusion Zones-- Haro Straight	WDFW		WA		No	commercial harvest of these species limited		No		Y	Y	Y	Y	Y	N	Y	Y	Y		Y	Y	Y	Y	Y
	Sea cucumber and urchin Exclusion Zone area San Juan and Upright Channels	WDFW		WA		No	commercial harvest of these species limited		No		Y	Y	Y	Y	Y	N	Y	Y	Y		Y	Y	Y	Y	Y
	Halibut and Bottomfish Closure Area (recreational fishing), Marine Area 3-La Push	WDFW		WA		No	fishing for halibut and bottomfish is closed and anglers may not fish for salmon with bottomfish aboard		No		Y	Y	Y	Y	Y	Y	Y	Y	Y		Y	Y	Y	Y	N
	Halibut and Bottomfish Closure Area (recreational fishing), Marine Area 4-Neah Bay	WDFW		WA		No	fishing for halibut and bottomfish is closed and anglers may not fish for salmon with bottomfish aboard		No		Y	Y	Y	Y	Y	Y	Y	Y	Y		Y	Y	Y	Y	N
	Dungeness Bay Closure (recreational fishing), Marine Area 6	WDFW		WA	see WDFW angling regs for map	No	closed to fishing for salmon July 1-Sept 30.		No		Y	Y	Y	Y	Y	Y	Y	Y	Y		Y	Y	Y	Y	Y
	Kydaka Point Closure, (recreational fishing) Marine Area 5- Sekiu and Pillar Point	WDFW		WA	see WDFW angling regs for map	No	closed to fishing for salmon July 1-Sept 30.		No		Y	Y	Y	Y	Y	Y	Y	Y	Y		Y	Y	Y	Y	Y
	Dungeness Bay Closure- (recreational fishing)Marine Area 6	WDFW		WA	see WDFW angling regs for map	No	closed to fishing for salmon Nov 1-Sept 30.		No		Y	Y	Y	Y	Y	Y	Y	Y	Y		Y	Y	Y	Y	Y
	Sequim Bay Shrimp District (recreational fishing)- Marine Area 6	WDFW		WA	see WDFW angling regs for map	No	closed to fishing for shrimp (includes spot, pink and coonstripe shrimp), also closed to fishing for box crab, Puget Sound King crab, abalone.		No		Y	Y	Y	Y	Y	Y	Y	Y	Y		Y	Y	Y	Y	Y
	Freshwater Bay Closure- (recreational fishing) Marine Area 6	WDFW		WA	see WDFW angling regs for map	No	closed to all fishing July 1- Aug 31		No		Y	Y	Y	Y	Y	Y	Y	Y	Y		Y	Y	Y	Y	Y
	Port Angeles Harbor Closure- (recreational fishing) Marine Area 6	WDFW		WA	see WDFW angling regs for map	No	closed to fishing for salmon July1-August 31		No		Y	Y	Y	Y	Y	Y	Y	Y	Y		Y	Y	Y	Y	Y

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	Bellingham Bay Closure- (recreational fishing) Marine Area 7	WDFW		WA	see WDFW angling regs for map	No	closed to fishing for salmon July 1-August 15.		No		Y	Y	Y	Y	Y	Y	Y	Y	Y		Y	Y	Y	Y	Y
	Samish Bay Closure- (recreational fishing) Marine Area 7	WDFW		WA	see WDFW angling regs for map	No	closed to fishing for salmon July 1-October 15.		No		Y	Y	Y	Y	Y	Y	Y	Y	Y		Y	Y	Y	Y	Y
	July Rosario Strait/Eastern Strait of Juan de Fuca Closure (recreational fishing)- Marine Area 7	WDFW		WA	see WDFW angling regs for map	No	closed to fishing for salmon July 1- July 31		No		Y	Y	Y	Y	Y	Y	Y	Y	Y		Y	Y	Y	Y	Y
	Aug-Sept. Rosario Strait/Eastern Strait of Juan de Fuca Closure- (recreational fishing) Marine Area 7	WDFW		WA	see WDFW angling regs for map	No	closed to fishing of salmon August 1- September 30.		No		Y	Y	Y	Y	Y	Y	Y	Y	Y		Y	Y	Y	Y	Y
	Tualip Bay Closure- Marine Area (recreational fishing) 8 2 Port Susan and Port Gardner	WDFW		WA	see WDFW angling regs for map	No	closed to fishing for salmon		No		Y	Y	Y	Y	Y	Y	Y	Y	Y		Y	Y	Y	Y	Y
	Edmonds Public Fishing Pier-(recreational fishing) Marine Area 9	WDFW		WA	see WDFW angling regs for map	No	closed to fishing for foodfish and to the harvest of shellfish except when fishing from pier.		No		Y	Y	Y	Y	Y	Y	Y	Y	N		N	N	N	N	Y
	Hood Canal Bridge fishing pontoon (recreational)	WDFW		WA	see WDFW angling regs for map	No	closed to fishing (2004) temporarily due to construction		No		Y	Y	Y	Y	Y	Y	N	N	N		Y	Y	Y	Y	N
	Puget Sound Naval Shipyard at Bremerton- (recreational fishing) Marine Area 10	WDFW		WA	see WDFW angling regs for map	No	closed to fishing for food fish at all times		No		Y	Y	Y	Y	Y	Y	N	N	Y		Y	Y	Y	Y	N
	Chittenden Locks Closure (recreational fishing)-Marine Area 10	WDFW		WA	see WDFW angling regs for map	No	closed to fishing for food fish		No		Y	Y	Y	Y	Y	Y	N	N	Y		N	N	N	N	N
	Elliott Bay Public Fish Pier- (recreational fishing) Marine Area 10	WDFW		WA	see WDFW angling regs for map	No	waters within 100 yards of the Elliott Bay Public Fishing Pier closed to fishing for food fish and the harvest of shellfish except when fishing from the pier.		No		Y	Y	Y	Y	Y	Y	Y	Y	Y		Y	Y	Y	Y	N
	Duwamish Waterways Special Rules- (recreational fishing)- area a-Marine Area 10	WDFW		WA	see WDFW angling regs for map	No	July 1- Oct 31, Unlawful to use forage fish jig gear, night closure, non-buoyant lure restriction.		No		Y	Y	Y	Y	Y	Y	Y	Y	Y		Y	Y	Y	Y	Y
	Duwamish Waterways Special Rules -(recreational fishing) area b-Marine Area 10	WDFW		WA	see WDFW angling regs for map	No	July 1- Oct 31, Terminal gear restricted to bait suspended above the bottom from a float.		No		Y	Y	Y	Y	Y	Y	Y	N	N		N	N	N	N	Y
	Agate Pass Closure- (recreational fishing) Marine Area 10	WDFW		WA	see WDFW angling regs for map	No	closed to all fishing Jan 1- March 31		No		Y	Y	Y	Y	Y	Y	Y	Y	Y		Y	Y	Y	Y	Y
	Shilshole Bay Closure- (recreational fishing) Marine Area 10	WDFW		WA	see WDFW angling regs for map	No	closed to fishing for salmon July 1- Aug 31		No		Y	Y	Y	Y	Y	Y	Y	Y	Y		Y	Y	Y	Y	Y
	Elliott Bay closure (recreational fishing)	WDFW		WA	see WDFW angling regs for map	No	closed to fishing for salmon July 1- Aug 31	does not include inner Elliott Bay Fishery	No		Y	Y	Y	Y	Y	Y	Y	Y	Y		Y	Y	Y	Y	Y
	Les Davis Fishing Pier- (recreational fishing) Marine Area 11	WDFW		WA	see WDFW angling regs for map	No	waters within 100 yards of the Les Davis Fishing Pier closed to fishing for food fish and the harvest of shellfish except when fishing from the pier.		No		Y	Y	Y	Y	Y	Y	Y	Y	Y		Y	Y	Y	Y	Y
	Des Moines Fishing Pier- (recreational fishing) Marine Area 11	WDFW		WA	see WDFW angling regs for map	No	waters within 100 yards of the Des Moines Public Fishing Pier closed to fishing for food fish and to the harvest of shellfish except when fishing from the pier		No		Y	Y	Y	Y	Y	Y	Y	Y	Y		Y	Y	Y	Y	Y
	Commencement Bay Closure (recreational fishing)	WDFW		WA	see WDFW angling regs for map	No	closed to fishing for salmon June 1- July 31.		No		Y	Y	Y	Y	Y	Y	Y	Y	Y		Y	Y	Y	Y	Y
	Enetai Hatchery Outfall Closure-(recreational fishing) Marine Area 12	WDFW		WA	see WDFW angling regs for map	No	closed year round to fishing for food fish	waters within 100 yards of the Enetai Hatchery outfall	No		Y	Y	Y	Y	Y	Y	N	N	Y		Y	Y	Y	Y	N
	Big Beef Closure- (recreational fishing) Marine Area 12	WDFW		WA	see WDFW angling regs for map	No	closed to fishing for food fish Aug 1 to Nov 30.	waters within 100 feet of the Sea Hwy NW Big Beed Creek Bridge	No		Y	Y	Y	Y	Y	Y	Y	Y	Y		Y	Y	Y	Y	Y
	Hoodsport Hatchery Zone (recreational)	WDFW		WA	see WDFW angling regs for map	No	open to fishing		No		Y	Y	Y	Y	Y	Y	Y	Y	Y		Y	Y	Y	Y	Y
	Hoodsport Hatchery Closure (recreational)	WDFW		WA	see WDFW angling regs for map	No	closed to fishing				Y	Y	Y	Y	Y	Y	N	N	N		Y	Y	Y	Y	N
	Carr Inlet Shrimp District Closure (recreational fishing) - Marine Area 13	WDFW		WA	see WDFW angling regs for map	No	Closed to fishing for shrimp year round (includes spot, pink and coonstripe shrimp), also closed to fishing for box crab, Puget Sound King crab, abalone Closed to fishing for salmon April 16- July 31 except open only to fly fishing for hatchery coho July 1-July 31. Waters at Minter Creek mouth wihtin 1000' of outer oyster stakes closed to fishing for salmon July 1-Sept 30.		No		Y	Y	Y	Y	Y	Y	Y	Y	Y		Y	Y	Y	Y	Y

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	Budd Inlet Closure (recreational fishing)-area South of Fourth Ave Brdg. (other continguous areas with seasonal closures)	WDFW		WA	see WDFW angling regs for map	No	waters of Budd inlet south of the Fourth Ave Bridge closed year round. All continguous waters between the Fourth Ave Bridge and a line drawn between the NW corner of the Thriftway Market to a point 100 yards north of the railraod bridge located on the western side of the inlet closed to fishing for salmon and bottomfish July 16-Oct. 31. North of this line to the area south of a line project true west from the KGY Radio Station Tower to the western shore of th Budd inlet has night closure and non-buoyant lure restrcitions in effect July 16-Oct 31.		No		Y	Y	Y	Y	Y	Y	N	N	N		Y	Y	Y	Y	N
	Puget Sound Commercial Salmon Fisheries Exclusion Zones (30 areas, 24 with complete salmon fishing closures)	WDFW		WA	see WDFW regulations, maps Pugest Sound Commercial Exlusion Zones	No	There are 24 areas where salmon fishing is closed, 3 areas where there are in-season area restrictions, and 3 areas with season closures in 2004.		No		Y	Y	Y	Y	N	Y	Y	Y	Y		Y	Y	Y	Y	Y
	Zella M. Shultz/Protection Island	WDFW/ USFWS	1975	WA		Yes	closed to public access			subtidal, intertidal	N	N	N	N	N	N	N	N	N		N	N	N	N	N
	Lummi Island	WDFW		WA		No	generally closed to public access, but not enforced		No	intertidal	N	N	N	N	N	N	N	N	N		N	N	N	N	N
	South Puget Sound	WDFW	1988	WA		Yes	non-consumptive recreational and educational use only			intertidal	N	N	N	N	N	N	N	N	N		N	N	N	N	N
	Skagit	WDFW	1948-1992	WA		No	commercial clamming may be prohibited ?		No																
	Maury Island Environmental Aquatic Reserve	WDNR	2003	WA		No	no restrictions on recreational and commercial fishing		No	Large herring spawning area; lot of eelgrass. Reserves designated for their environmental importance will be managed so as to preven land uses in or near the reserve that would conflict with protection of the environmental values of the area, e.g. leases for structures or activities would not be allowed if they would have the potential to degrade water quality, alter local currents, damage marine life or increase vessel traffic. Currently (July 2003) no aquatic plant harvest occurs here, but no rules to restrict; considering policy for no net loss of aquatic vegeation.	Y	Y	Y	Y	Y	Y	Y	Y	Y		Y	Y	Y	Y	Y
	Fidalgo Bay Environmental Aquatic Reserve	WDNR	2003	WA		No	no restrictions on recreational and commercial fishing		No	Reserves designated for their environmental importance will be managed so as to preven land uses in or near the reserve that would conflict with protection of the environmental values of the area, e.g. leases for structures or activities would not be allowed if they would have the potential to degrade water quality, alter local currents, damage marine life or increase vessel traffic.	Y	Y	Y	Y	Y	Y	Y	Y	Y		Y	Y	Y	Y	Y
	Cypress Island Environmental Aquatic Reserve	WDNR	2003	WA		No	no restrictions on recreational and commercial fishing		No	Reserves designated for their environmental importance will be managed so as to preven land uses in or near the reserve that would conflict with protection of the environmental values of the area, e.g. leases for structures or activities would not be allowed if they would have the potential to degrade water quality, alter local currents, damage marine life or increase vessel traffic.	Y	Y	Y	Y	Y	Y	Y	Y	Y		Y	Y	Y	Y	Y
	Cherry Point Environmental Aquatic Reserve	WDNR	2003	WA		No	no restrictions on recreational and commercial fishing		No	Largest herring spawning area in state. Reserves designated for their environmental importance will be managed so as to preven land uses in or near the reserve that would conflict with protection of the environmental values of the area, e.g. leases for structures or activities would not be allowed if they would have the potential to degrade water quality, alter local currents, damage marine life or increase vessel traffic.	Y	Y	Y	Y	Y	Y	Y	Y	Y		Y	Y	Y	Y	Y
	Olympic View-lease withdrawal area	WDNR	2004	WA		No	no restrictions on recreational and commercial fishing		No	site considered for Environmental Aquatic Reserve status, but not designated; howeve state will not lease lands within (withdrawn from leasing) since this site are undergoing restoration. Potential future candidate for other category of aquatic reserve status (e.g educational or scientific reserve status).	Y	Y	Y	Y	Y	Y	Y	Y	Y		Y	Y	Y	Y	Y
	Middle Waterway-lease withdrawal area	WDNR	2004	WA		No	no restrictions on recreational and commercial fishing		No	site considered for Environmental Aquatic Reserve status, but not designated; howeve state will not lease lands within (withdrawn from leasing) since this site are undergoing restoration. Potential future candidate for other category of aquatic reserve status (e.g educational or scientific reserve status).	Y	Y	Y	Y	Y	Y	Y	Y	Y		Y	Y	Y	Y	Y
	Bone River Natural Area Preserve	WDNR		WA		No	scientific research projects and education functions, but closed to all other activies			includes intertidal area. Total site is 2565 acres, contains the best salt marshes remaining in Willapa Bay, including tideflats, sloughs, fresh water wetlands, streams, and forested uplands	N	N	N	N	N	N	N	N	N		N	N	N	N	N
	Dabob Bay Natural Area Preserve (NAP)	WDNR	1987	WA		Yes	scientific research projects and education functions, but closed to all other activies			intertidal, site is 356 acres includes tidelands and forested slopes	N	N	N	N	N	N	N	N	N		N	N	N	N	N
	Chehalis River Surge Plain NAP	WDNR		WA		Yes	scientific research projects and education functions, but closed to all other activies			estuarine, 2643 acre site, including estuary, sloughs, forest	N	N	N	N	N	N	N	N	N		N	N	N	N	N
	Goose Island Natural Area Preserve	WDNR		WA		Yes	scientific research projects and education functions, but closed to all other activies			includes intertidal area. Site is a 12 acre sandy island	N	N	N	N	N	N	N	N	N		N	N	N	N	N
	Gunpowder Island Natural Area Preserve	WDNR		WA		Yes	scientific research projects and education functions, but closed to all other activies			includes intertidal area. Site is 156 acres on a sand island.	N	N	N	N	N	N	N	N	N		N	N	N	N	N
	Kennedy Creek Natural Area Preserve	WDNR	1990	WA		Yes	scientific research projects and education functions, but closed to all other activies			intertidal, estuarine. Site is 164 acre tidal river marsh.	N	N	N	N	N	N	N	N	N		N	N	N	N	N
	Niawiakum River Natural Area Preserve	WDNR		WA		Yes	scientific research projects and education functions, but closed to all other activies			includes intertidal area. Site is 838 acres including salt marsh, tidal river system	N	N	N	N	N	N	N	N	N		N	N	N	N	N
	Sand Island Natural Area Preserve	WDNR		WA		Yes	scientific research projects and education functions, but closed to all other activies			includes intertidal area. Site is a 8 acre sandy island.	N	N	N	N	N	N	N	N	N		N	N	N	N	N
	Skookum Inlet Natural Area Preserve	WDNR	1987	WA		Yes	scientific research projects and education functions, but closed to all other activies			includes intertidal area. Site is 143 acres, including tideflats, saltmarsh, and upland forest	N	N	N	N	N	N	N	N	N		N	N	N	N	N

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	Cattle Point Natural Resources Conservation Area (NRCA)	WDNR		WA		No	Management of Natural Resource Conservation Areas (NRCA) is determined site by site. Fishing opportunities allowed unless specific impacts on designated resources.	NRCA are designated to protect outstanding examples of native ecosystems, habitat for T & E species, and scenic landscapes. Environmental education and low impact public use (e.g. photography, birdwatching, hiking) allowed in non-senstive areas		includes intertidal area, total site is 112 acres including two waterfront parcels	Y	Y	Y	Y	Y	Y	Y	Y	Y		Y	Y	Y	Y	Y
	Elk River NRCA	WDNR		WA		No	Management of Natural Resource Conservation Areas (NRCA) is determined site by site. Fishing opportunities allowed unless specific impacts on designated resources.	NRCA are designated to protect outstanding examples of native ecosystems, habitat for T & E species, and scenic landscapes. Environmental education and low impact public use (e.g. photography, birdwatching, hiking) allowed in non-senstive areas		intertidal, 4362 acres,tideflats, sloughs, saltmarsh and freshwater wetlands, forested uplands. Largest, highest quality estuarine system remaining in Washington or Oregon.	Y	Y	Y	Y	Y	Y	Y	Y	Y		Y	Y	Y	Y	Y
	Hat Island NRCA	WDNR		WA		No	Management of Natural Resource Conservation Areas (NRCA) is determined site by site. Fishing opportunities allowed unless specific impacts on designated resources.	NRCA are designated to protect outstanding examples of native ecosystems, habitat for T & E species, and scenic landscapes. Environmental education and low impact public use (e.g. photography, birdwatching, hiking) allowed in non-senstive areas		Includes intertidal area. Total site is 91 acres, forested and grassy uplands	Y	Y	Y	Y	Y	Y	Y	Y	Y		Y	Y	Y	Y	Y
	Lummi Island NRCA	WDNR		WA		No	Management of Natural Resource Conservation Areas (NRCA) is determined site by site. Fishing opportunities allowed unless specific impacts on designated resources.	NRCA are designated to protect outstanding examples of native ecosystems, habitat for T & E species, and scenic landscapes. Environmental education and low impact public use (e.g. photography, birdwatching, hiking) allowed in non-senstive areas		includes small marine park for boaters, total site is 661 acres, uplands, rocky headlands	Y	Y	Y	Y	Y	Y	Y	Y	Y		Y	Y	Y	Y	Y
	Shipwreck Point NRCA	WDNR		WA		No	Management of Natural Resource Conservation Areas (NRCA) is determined site by site. Fishing opportunities allowed unless specific impacts on designated resources.	NRCA are designated to protect outstanding examples of native ecosystems, habitat for T & E species, and scenic landscapes. Environmental education and low impact public use (e.g. photography, birdwatching, hiking) allowed in non-senstive areas		includes intertidal area. Total site is 472 acres including tidal beaches, forested uplands.	Y	Y	Y	Y	Y	Y	Y	Y	Y		Y	Y	Y	Y	Y
	Woodard Bay Natural Resource Conservation Area (NRCA)	WDNR	1987	WA		No	Management of Natural Resource Conservation Areas (NRCA) is determined site by site. Fishing opportunities allowed unless specific impacts on designated resources.	NRCA are designated to protect outstanding examples of native ecosystems, habitat for T & E species, and scenic landscapes. Environmental education and low impact public use (e.g. photography, birdwatching, hiking) allowed in non-senstive areas		includes intertidal area. Total site is 678 acres, includes shoreland, wetlands, forested uplands	Y	Y	Y	Y	Y	Y	Y	Y	Y		Y	Y	Y	Y	Y
	Sequim Bay State Park	WPRC		WA		No	no harvest of non-game invertebrates, no algae harvest		Yes	subtidal, intertidal	Y	Y	Y	Y	Y	Y	Y	Y	Y		Y	Y	Y	Y	Y
	Fort Flagler State Park	WPRC		WA		No	no harvest of non-game invertebrates		No	subtidal, intertidal	Y	Y	Y	Y	Y	Y	Y	Y	Y		Y	Y	Y	Y	Y
	Fort Worden State Park	WPRC		WA		No	no harvest of non-game invertebrates		No	subtidal, intertidal	Y	Y	Y	Y	Y	Y	Y	Y	Y		Y	Y	Y	Y	Y
	Mystery Bay Marine State Park	WPRC		WA		No	no harvest of non-game invertebrates, no algae harvest		Yes	subtidal, intertidal	Y	Y	Y	Y	Y	Y	Y	Y	Y		Y	Y	Y	Y	Y
	Old Fort Townsend State Park	WPRC		WA		No	no harvest of non-game invertebrates, no algae harvest		Yes	subtidal, intertidal	Y	Y	Y	Y	Y	Y	Y	Y	Y		Y	Y	Y	Y	Y
	Pleasant Harbor Bay State Park	WPRC		WA		No	no harvest of non-game invertebrates, no algae harvest		Yes	subtidal, intertidal	Y	Y	Y	Y	Y	Y	Y	Y	Y		Y	Y	Y	Y	Y
	Triton Cove State Park	WPRC		WA		No	no harvest of non-game invertebrates, no algae harvest		Yes	subtidal, intertidal	Y	Y	Y	Y	Y	Y	Y	Y	Y		Y	Y	Y	Y	Y
	Dash Point State Park	WPRC		WA		No	no harvest of non-game invertebrates, no algae harvest		Yes	subtidal, intertidal	Y	Y	Y	Y	Y	Y	Y	Y	Y		Y	Y	Y	Y	Y
	Saltwater State Park	WPRC		WA		No	no harvest of non-game invertebrates, no algae harvest		Yes	subtidal, intertidal	Y	Y	Y	Y	Y	Y	Y	Y	Y		Y	Y	Y	Y	Y
	Blake Island State Park	WPRC		WA		No	no harvest of non-game invertebrates, no algae harvest		Yes	subtidal, intertidal	Y	Y	Y	Y	Y	Y	Y	Y	Y		Y	Y	Y	Y	Y
	Fay-Bainbridge State Park	WPRC		WA		No	no harvest of non-game invertebrates, no algae harvest		Yes	subtidal, intertidal	Y	Y	Y	Y	Y	Y	Y	Y	Y		Y	Y	Y	Y	Y
	Camano Island State Park	WPRC		WA		No	no harvest of non-game invertebrates, no algae harvest		Yes	subtidal, intertidal	Y	Y	Y	Y	Y	Y	Y	Y	Y		Y	Y	Y	Y	Y
	Fort Ward State Park	WPRC		WA		No	no harvest of non-game invertebrates, no algae harvest		Yes	subtidal, intertidal	Y	Y	Y	Y	Y	Y	Y	Y	Y		Y	Y	Y	Y	Y
	Harper State Park	WPRC		WA		No	no harvest of non-game invertebrates, no algae harvest		Yes	subtidal, intertidal	Y	Y	Y	Y	Y	Y	Y	Y	Y		Y	Y	Y	Y	Y
	Illahee State Park	WPRC		WA		No	no harvest of non-game invertebrates, no algae harvest		Yes	subtidal, intertidal	Y	Y	Y	Y	Y	Y	Y	Y	Y		Y	Y	Y	Y	Y
	Kitsap Memorial State Park	WPRC		WA		No	no harvest of non-game invertebrates, no algae harvest		Yes	subtidal, intertidal	Y	Y	Y	Y	Y	Y	Y	Y	Y		Y	Y	Y	Y	Y
	Manchester State Park	WPRC		WA		No	no harvest of non-game invertebrates, no algae harvest		Yes	subtidal, intertidal	Y	Y	Y	Y	Y	Y	Y	Y	Y		Y	Y	Y	Y	Y
	Old Man House State Park	WPRC		WA		No	no harvest of non-game invertebrates, no algae harvest		Yes	subtidal, intertidal	Y	Y	Y	Y	Y	Y	Y	Y	Y		Y	Y	Y	Y	Y
	Scenic Beach State Park	WPRC		WA		No	no harvest of non-game invertebrates, no algae harvest		Yes	subtidal, intertidal	Y	Y	Y	Y	Y	Y	Y	Y	Y		Y	Y	Y	Y	Y
	Belfair State Park	WPRC		WA		No	no harvest of non-game invertebrates, no algae harvest		Yes	subtidal, intertidal	Y	Y	Y	Y	Y	Y	Y	Y	Y		Y	Y	Y	Y	Y
	Harstine Island State Park	WPRC		WA		No	no harvest of non-game invertebrates, no algae harvest		Yes	subtidal, intertidal	Y	Y	Y	Y	Y	Y	Y	Y	Y		Y	Y	Y	Y	Y
	Hope Island (S.) Marine State Park	WPRC		WA		No	no harvest of non-game invertebrates, no algae harvest		Yes	subtidal, intertidal	Y	Y	Y	Y	Y	Y	Y	Y	Y		Y	Y	Y	Y	Y
	Deception Park State Park	WPRC		WA		No	no harvest of non-game invertebrates, no algae harvest		Yes	subtidal, intertidal	Y	Y	Y	Y	Y	Y	Y	Y	Y		Y	Y	Y	Y	Y
	Jarrell Cove State Park	WPRC		WA		No	no harvest of non-game invertebrates, no algae harvest		Yes	subtidal, intertidal	Y	Y	Y	Y	Y	Y	Y	Y	Y		Y	Y	Y	Y	Y
	McMicken Is. Marine State Park	WPRC		WA		No	no harvest of non-game invertebrates, no algae harvest		Yes	subtidal, intertidal	Y	Y	Y	Y	Y	Y	Y	Y	Y		Y	Y	Y	Y	Y
	Potlach State Park	WPRC		WA		No	no harvest of non-game invertebrates, no algae harvest		Yes	subtidal, intertidal	Y	Y	Y	Y	Y	Y	Y	Y	Y		Y	Y	Y	Y	Y
	Squaxin Island State Park	WPRC		WA		No	no harvest of non-game invertebrates, no algae harvest		Yes	subtidal, intertidal	Y	Y	Y	Y	Y	Y	Y	Y	Y		Y	Y	Y	Y	Y
	Stretch Point State Park	WPRC		WA		No	no harvest of non-game invertebrates, no algae harvest		Yes	subtidal, intertidal	Y	Y	Y	Y	Y	Y	Y	Y	Y		Y	Y	Y	Y	Y
	Twanoh State Park	WPRC		WA		No	no harvest of non-game invertebrates, no algae harvest		Yes	subtidal, intertidal	Y	Y	Y	Y	Y	Y	Y	Y	Y		Y	Y	Y	Y	Y
	Cutts Island Marine State Park	WPRC		WA		No	no harvest of non-game invertebrates, no algae harvest		Yes	subtidal, intertidal	Y	Y	Y	Y	Y	Y	Y	Y	Y		Y	Y	Y	Y	Y
	Eagle Island Marine State Park	WPRC		WA		No	no harvest of non-game invertebrates, no algae harvest		Yes	subtidal, intertidal	Y	Y	Y	Y	Y	Y	Y	Y	Y		Y	Y	Y	Y	Y
	Joemma Beach State Park	WPRC		WA		No	no harvest of non-game invertebrates, no algae harvest		Yes	subtidal, intertidal	Y	Y	Y	Y	Y	Y	Y	Y	Y		Y	Y	Y	Y	Y
	Kopachuck State Park	WPRC		WA		No	no harvest of non-game invertebrates, no algae harvest		Yes	subtidal, intertidal	Y	Y	Y	Y	Y	Y	Y	Y	Y		Y	Y	Y	Y	Y
	Ebey's Landing State Park	WPRC		WA		No	no harvest of non-game invertebrates, no algae harvest		Yes	subtidal, intertidal	Y	Y	Y	Y	Y	Y	Y	Y	Y		Y	Y	Y	Y	Y

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	Penrose Point State Park	WPRC		WA		No	no harvest of non-game invertebrates, no algae harvest		Yes	subtidal, intertidal	Y	Y	Y	Y	Y	Y	Y	Y	Y		Y	Y	Y	Y	Y
	Blind Island Marine State Park	WPRC		WA		No	no harvest of non-game invertebrates, no algae harvest		Yes	subtidal, intertidal	Y	Y	Y	Y	Y	Y	Y	Y	Y		Y	Y	Y	Y	Y
	Clark Island Marine State Park	WPRC		WA		No	no harvest of non-game invertebrates, no algae harvest		Yes	subtidal, intertidal	Y	Y	Y	Y	Y	Y	Y	Y	Y		Y	Y	Y	Y	Y
	Doe Island Marine State Park	WPRC		WA		No	no harvest of non-game invertebrates, no algae harvest		Yes	subtidal, intertidal	Y	Y	Y	Y	Y	Y	Y	Y	Y		Y	Y	Y	Y	Y
	James Island Marine State Park	WPRC		WA		No	no harvest of non-game invertebrates, no algae harvest		Yes	subtidal, intertidal	Y	Y	Y	Y	Y	Y	Y	Y	Y		Y	Y	Y	Y	Y
	Jones Island Marine State Park	WPRC		WA		No	no harvest of non-game invertebrates, no algae harvest		Yes	subtidal, intertidal	Y	Y	Y	Y	Y	Y	Y	Y	Y		Y	Y	Y	Y	Y
	Lime Kiln State Park	WPRC		WA		No	no harvest of non-game invertebrates, no algae harvest		Yes	subtidal, intertidal	Y	Y	Y	Y	Y	Y	Y	Y	Y		Y	Y	Y	Y	Y
	Matia Island Marine State Park	WPRC		WA		No	no harvest of non-game invertebrates, no algae harvest		Yes	subtidal, intertidal	Y	Y	Y	Y	Y	Y	Y	Y	Y		Y	Y	Y	Y	Y
	Moran State Park	WPRC		WA		No	no harvest of non-game invertebrates, no algae harvest		Yes	subtidal, intertidal	Y	Y	Y	Y	Y	Y	Y	Y	Y		Y	Y	Y	Y	Y
	Patos Island Marine State Park	WPRC		WA		No	no harvest of non-game invertebrates, no algae harvest		Yes	subtidal, intertidal	Y	Y	Y	Y	Y	Y	Y	Y	Y		Y	Y	Y	Y	Y
	Fort Casey State Park	WPRC		WA		No	no harvest of non-game invertebrates, no algae harvest		Yes	subtidal, intertidal	Y	Y	Y	Y	Y	Y	Y	Y	Y		Y	Y	Y	Y	Y
	Posey Island Marine State Park	WPRC		WA		No	no harvest of non-game invertebrates, no algae harvest		Yes	subtidal, intertidal	Y	Y	Y	Y	Y	Y	Y	Y	Y		Y	Y	Y	Y	Y
	Spencer Spit State Park	WPRC		WA		No	no harvest of non-game invertebrates, no algae harvest		Yes	subtidal, intertidal	Y	Y	Y	Y	Y	Y	Y	Y	Y		Y	Y	Y	Y	Y
	Stuart Island Marine State Park	WPRC		WA		No	no harvest of non-game invertebrates, no algae harvest		Yes	subtidal, intertidal	Y	Y	Y	Y	Y	Y	Y	Y	Y		Y	Y	Y	Y	Y
	Sucia Island Marine State Park	WPRC		WA		No	no harvest of non-game invertebrates, no algae harvest		Yes	subtidal, intertidal	Y	Y	Y	Y	Y	Y	Y	Y	Y		Y	Y	Y	Y	Y
	Turn Island Marine State Park	WPRC		WA		No	no harvest of non-game invertebrates, no algae harvest		Yes	subtidal, intertidal	Y	Y	Y	Y	Y	Y	Y	Y	Y		Y	Y	Y	Y	Y
	Bay View State Park	WPRC		WA		No	no harvest of non-game invertebrates, no algae harvest		Yes	subtidal, intertidal	Y	Y	Y	Y	Y	Y	Y	Y	Y		Y	Y	Y	Y	Y
	Larrabee State Park	WPRC		WA		No	no harvest of non-game invertebrates, no algae harvest		Yes	subtidal, intertidal	Y	Y	Y	Y	Y	Y	Y	Y	Y		Y	Y	Y	Y	Y
	Saddlebag Island Marine State Park	WPRC		WA		No	no harvest of non-game invertebrates, no algae harvest		Yes	subtidal, intertidal	Y	Y	Y	Y	Y	Y	Y	Y	Y		Y	Y	Y	Y	Y
	Mukilteo State Park	WPRC		WA		No	no harvest of non-game invertebrates, no algae harvest		Yes	subtidal, intertidal	Y	Y	Y	Y	Y	Y	Y	Y	Y		Y	Y	Y	Y	Y
	Tolmie State Park	WPRC		WA		No	no harvest of non-game invertebrates, no algae harvest		Yes	subtidal, intertidal	Y	Y	Y	Y	Y	Y	Y	Y	Y		Y	Y	Y	Y	Y
	Fort Ebey State Park	WPRC		WA		No	no harvest of non-game invertebrates		No	subtidal, intertidal	Y	Y	Y	Y	Y	Y	Y	Y	Y		Y	Y	Y	Y	Y
	Birch Bay State Park	WPRC		WA		No	no harvest of non-game invertebrates, no algae harvest		Yes	subtidal, intertidal	Y	Y	Y	Y	Y	Y	Y	Y	Y		Y	Y	Y	Y	Y
	Joseph Whidbey State Park	WPRC		WA		No	no harvest of non-game invertebrates, no algae harvest		Yes	subtidal, intertidal	Y	Y	Y	Y	Y	Y	Y	Y	Y		Y	Y	Y	Y	Y
	South Whidbey State Park	WPRC		WA		No	no harvest of non-game invertebrates, no algae harvest		Yes	subtidal, intertidal	Y	Y	Y	Y	Y	Y	Y	Y	Y		Y	Y	Y	Y	Y
	Dosewallips State Park	WPRC		WA		No	no harvest of non-game invertebrates, no algae harvest		Yes	subtidal, intertidal	Y	Y	Y	Y	Y	Y	Y	Y	Y		Y	Y	Y	Y	Y
	Pacific Beach State Park	WPRC		WA			no harvest of non-game invertebrates, no algae harvest		Yes		Y	Y	Y	Y	Y	Y	Y	Y	Y		Y	Y	Y	Y	Y
	Griffiths-Priday State Park	WPRC		WA			no harvest of non-game invertebrates, no algae harvest		Yes		Y	Y	Y	Y	Y	Y	Y	Y	Y		Y	Y	Y	Y	Y
	Ocean City State Park	WPRC		WA			no harvest of non-game invertebrates, no algae harvest		Yes		Y	Y	Y	Y	Y	Y	Y	Y	Y		Y	Y	Y	Y	Y
	Wethaven State Park	WPRC		WA			no harvest of non-game invertebrates, no algae harvest		Yes		Y	Y	Y	Y	Y	Y	Y	Y	Y		Y	Y	Y	Y	Y
	Westport Light State Park	WPRC		WA			no harvest of non-game invertebrates, no algae harvest		Yes		Y	Y	Y	Y	Y	Y	Y	Y	Y		Y	Y	Y	Y	Y
	Twin Harbors State Park	WPRC		WA			no harvest of non-game invertebrates, no algae harvest		Yes		Y	Y	Y	Y	Y	Y	Y	Y	Y		Y	Y	Y	Y	Y
	Grayland Beach State Park	WPRC		WA			no harvest of non-game invertebrates, no algae harvest		Yes		Y	Y	Y	Y	Y	Y	Y	Y	Y		Y	Y	Y	Y	Y
	Leadbetter Point State Park	WPRC		WA			no harvest of non-game invertebrates, no algae harvest		Yes		Y	Y	Y	Y	Y	Y	Y	Y	Y		Y	Y	Y	Y	Y
	Pacific Pines State Park	WPRC		WA			no harvest of non-game invertebrates, no algae harvest		Yes		Y	Y	Y	Y	Y	Y	Y	Y	Y		Y	Y	Y	Y	Y
	Loomis Lake State Park	WPRC		WA			no harvest of non-game invertebrates, no algae harvest		Yes		Y	Y	Y	Y	Y	Y	Y	Y	Y		Y	Y	Y	Y	Y
	Fort Canby State Park	WPRC		WA			no harvest of non-game invertebrates, no algae harvest		Yes		Y	Y	Y	Y	Y	Y	Y	Y	Y		Y	Y	Y	Y	Y
	Fort Columbia State Park	WPRC		WA			no harvest of non-game invertebrates, no algae harvest		Yes		Y	Y	Y	Y	Y	Y	Y	Y	Y		Y	Y	Y	Y	Y
	Washington State Seashore Conservation Area	WPRC		WA			no harvest of non-game invertebrates, no algae harvest		Yes		Y	Y	Y	Y	Y	Y	Y	Y	Y		Y	Y	Y	Y	Y
	Kimball Preserve, Decatur Island	San Juan Preservation Trust	1985	WA		Yes	no public access			intertidal	N	N	N	N	N	N	N	N	N		N	N	N	N	N
	Yellow Island	TNC	1980	WA		Yes	no fishing and no collection of plants or animals whil on preserve property; limited public access		Yes	intertidal	N	N	N	N	N	N	N	N	N		N	N	N	N	N
	Chuckanut Island	TNC	1972	WA		Yes	no fishing and no collection of plants or animals whil on preserve property; limited public access		Yes	intertidal	N	N	N	N	N	N	N	N	N		N	N	N	N	N
	Foulweather Bluff	TNC	1966	WA		Yes	no fishing and no collection of plants or animals whil on preserve property; limited public access		Yes	intertidal	N	N	N	N	N	N	N	N	N		N	N	N	N	N
	Sentinel Island	TNC	1979	WA		Yes	no fishing and no collection of plants or animals whil on preserve property; limited public access		Yes	intertidal	N	N	N	N	N	N	N	N	N		N	N	N	N	N
	Waldron Island	TNC	1968	WA		Yes	no fishing and no collection of plants or animals whil on preserve property; limited public access		Yes	intertidal	N	N	N	N	N	N	N	N	N		N	N	N	N	N
	Goose Island	TNC	1975	WA		Yes	no public access			intertidal	N	N	N	N	N	N	N	N	N		N	N	N	N	N
	Deadman Island	TNC	1975	WA		Yes	no public access			intertidal	N	N	N	N	N	N	N	N	N		N	N	N	N	N
	Tongue Point	Clallam County	1989	WA		No	removal of any marine life by permit only, except sport fishing is allowed and clams, crabs and mussels can be gathered in season		Yes	subtidal, intertidal	N	N	N	N	N	N	Y	Y	Y		N	N	N	N	Y
	Point Lawrence	San Juan County	1997	WA		No	Voluntary no-take of bottomfish			subtidal, intertidal	Y	Y	Y	Y	Y	Y	Y	Y	Y		Y	Y	Y	Y	Y
	Bell Island	San Juan County	1997	WA		No	Voluntary no-take of bottomfish			subtidal, intertidal	Y	Y	Y	Y	Y	Y	Y	Y	Y		Y	Y	Y	Y	Y
	Charles Island	San Juan County	1997	WA		No	Voluntary no-take of bottomfish			subtidal, intertidal	Y	Y	Y	Y	Y	Y	Y	Y	Y		Y	Y	Y	Y	Y
	Pile Point	San Juan County	1997	WA		No	Voluntary no-take of bottomfish			subtidal, intertidal	Y	Y	Y	Y	Y	Y	Y	Y	Y		Y	Y	Y	Y	Y
	Lime Kilm Lighthouse	San Juan County	1997	WA		No	Voluntary no-take of bottomfish			subtidal, intertidal	Y	Y	Y	Y	Y	Y	Y	Y	Y		Y	Y	Y	Y	Y
	Kellett Bluff	San Juan County	1997	WA		No	Voluntary no-take of bottomfish			subtidal, intertidal	Y	Y	Y	Y	Y	Y	Y	Y	Y		Y	Y	Y	Y	Y
	Gull Rock	San Juan County	1997	WA		No	Voluntary no-take of bottomfish			subtidal, intertidal	Y	Y	Y	Y	Y	Y	Y	Y	Y		Y	Y	Y	Y	Y
	Bare Island	San Juan County	1997	WA		No	Voluntary no-take of bottomfish			subtidal, intertidal	Y	Y	Y	Y	Y	Y	Y	Y	Y		Y	Y	Y	Y	Y
Oregon																									
	Haystack Rock Marine Garden	ODFW	1960	OR		No	closed to recreational and commercial take of shellfish and marine invertebrates except single mussels may be taken for bait		Yes	intertidal	Y	Y	Y	N	Y	Y	Y	N	Y		Y	Y	N	Y	Y

SITE_ID	FULLNAME	AGENCY	YEAR ESTABLISHED	STATE	GIS layer updated?	Is this area closed to all fishing by regulations specific to the site?	Fishing Regulations **specific to the site's designation**	OTHER FISHING RELATED NOTES (R = recreational fishing, C = commercial fishing)	KELP or seaweed harvest restricted by rules specific to site?	OTHER INFORMATION	Is TRAWL gear allowed? (bottom, mid water, shrimp, beam trawls)	Are other NETS allowed? (seine, gillnet, salmon reefnet, demersal seine)	Is DREDGE gear allowed?	Is commer-cial POT gear allowed?	Is commer-cial HOOK & LINE gear allowed?	Is OTHER commer-cial fishing gear allowed?	Is recreational HOOK & LINE gear allowed?	Is recrea-tional POT gear allowed?	Are OTHER recrea-tional fishing gears allowed?		Is Groundfish Bottom Trawl gear allowed?	Is Groundfish Longline gear allowed?	Is Groundfish pot gear allowed?	Is Groundfish mid-water TRAWL gear allowed?	Is recrea-tional Groundfish gear allowed?
	Cape Kiwanda Marine Garden	ODFW	1997	OR		No	closed to recreational and commercial take of shellfish and marine invertebrates except single mussels may be taken for bait		Yes	intertidal	Y	Y	Y	N	Y	Y	Y	N	Y		Y	Y	Y	Y	Y
	Otter Rock Marine Garden	ODFW	1960	OR		No	closed to recreational and commercial take of shellfish and marine invertebrates except single mussels may be taken for bait		Yes	intertidal	Y	Y	Y	N	Y	Y	Y	N	Y		Y	Y	Y	Y	Y
	Yaquina Head Marine Garden	ODFW	1960s	OR		No	closed to recreational and commercial take of shellfish and marine invertebrates except single mussels may be taken for bait		Yes	intertidal	Y	Y	Y	N	Y	Y	Y	N	Y		Y	Y	Y	Y	Y
	Yachats Marine Garden	ODFW	1977	OR		No	closed to recreational and commercial take of shellfish and marine invertebrates except single mussels may be taken for bait		Yes	intertidal	Y	Y	Y	N	Y	Y	Y	N	Y		Y	Y	Y	Y	Y
	Cape Perpetua Marine Garden	ODFW	1960s	OR		No	closed to recreational and commercial take of shellfish and marine invertebrates except single mussels may be taken for bait		Yes	intertidal	Y	Y	Y	N	Y	Y	Y	N	Y		Y	Y	Y	Y	Y
	Harris Beach Marine Garden	ODFW	1960s	OR		No	closed to recreational and commercial take of shellfish and marine invertebrates except single mussels may be taken for bait		Yes	intertidal	Y	Y	Y	N	Y	Y	Y	N	Y		Y	Y	Y	Y	Y
	Netarts Bay Shellfish Preserve	ODFW	late 1960s or early 1970s	OR		No	closed to the taking of clams		No	subtidal and intertidal area; incidentally protects high and low salt marsh, sand and mixed sand/mud, and seagrass beds	Y	Y	Y	Y	Y	Y	Y	Y	Y		Y	Y	Y	Y	Y
	Yaquina Bay Shellfish Preserve	ODFW	late 1960s or early 1970s	OR		No	closed to the taking of clams		No	subtidal and intertidal area; incidentally protects high and low salt marsh, sand and mixed sand/mud, and seagrass beds	Y	Y	Y	Y	Y	Y	Y	Y	Y		Y	Y	Y	Y	Y
	Three Arch Rocks (Oceanside)	Oregon State Marine Board		OR		No	closed to boats 500 feet around the main rocks (Finley Rock, Middle Rock, Shag Rock, and Seal Rock) May 1- Sept 15		No	Subtidal. No fishing restrictions per say--only access restrictions seasonally	Y	Y	Y	Y	Y	Y	Y	Y	Y		Y	Y	Y	Y	Y
	Pyramid Rock (Rogue Reef)	ODFW		OR		No	closed to take of marine fish, shellfish, and marine invertebrates from 1000 feet around and including Pyramid rock from May 1 to Aug 31		No	subtidal	Y	Y	Y	Y	Y	Y	Y	Y	Y		Y	Y	Y	Y	Y
	Pirates Cove Subtidal Research Reserve	ODFW	1960	OR		No	Closed to the taking of recreational and commercial shellfish and marine invertebrates except scientific permits may be issued for scientific and educational purposes.		Yes, except for scientific and educational purposes	subtidal	Y	Y	Y	N	Y	Y	Y	N	Y		Y	Y	Y	Y	Y
	Gregory Point Subtidal Research Reserve	ODFW	1960s	OR		No	Closed to the taking of recreational and commercial shellfish and marine invertebrates except scientific permits may be issued for scientific and educational purposes.		Yes, except for scientific and educational purposes	subtidal	Y	Y	Y	N	Y	Y	Y	N	Y		Y	Y	Y	Y	Y
	Boiler Bay Intertidal Research Reserve	ODFW	1960s	OR		No	Closed to the commercial and recreational taking of shellfish and marine invertebrates except for recreational purposes abalone, clams, Dungeness crab, red rock crab, mussels, piddocks, scallops and shrimp (edible and bait) may be taken. Scientific permits may be issued for scientific and educational purposes.		Yes, except for scientific and educational purposes	intertidal	Y	Y	Y	N	Y	Y	Y	Y	Y		Y	Y	Y	Y	Y
	Neptune State Park Intertidal Research Reserve	ODFW	1960s	OR		No	Closed to the commercial and recreational taking of shellfish and marine invertebrates except for recreational purposes abalone, clams, Dungeness crab, red rock crab, mussels, piddocks, scallops and shrimp (edible and bait) may be taken. Scientific permits may be issued for scientific and educational purposes.		Yes, except for scientific and educational purposes	intertidal	Y	Y	Y	N	Y	Y	Y	Y	Y		Y	Y	Y	Y	Y
	Cape Arago Intertidal Research Reserve (Area B)	ODFW	1960s	OR		No	Closed to the commercial and recreational taking of shellfish and marine invertebrates except for recreational purposes abalone, clams, Dungeness crab, red rock crab, mussels, piddocks, scallops and shrimp (edible and bait) may be taken. Scientific permits may be issued for scientific and educational purposes.		Yes, except for scientific and educational purposes	intertidal	Y	Y	Y	N	Y	Y	Y	Y	Y		Y	Y	Y	Y	Y
	Cape Arago Intertidal Research Reserve (Areas A,C)	ODFW		OR		No	Closed to the recreational and commercial take of all shellfish and marine invertebrates. Scientific permits may be issued for scientific and education al purposes.		Yes, except for scientific and educational purposes	intertidal	Y	Y	Y	N	Y	Y	Y	N	Y		Y	Y	Y	Y	Y
	Brookings Intertidal Research Reserve	ODFW	1960s	OR		No	Closed to the commercial and recreational taking of shellfish and marine invertebrates except for recreational purposes abalone, clams, Dungeness crab, red rock crab, mussels, piddocks, scallops and shrimp (edible and bait) may be taken. Scientific permits may be issued for scientific and educational purposes.		Yes, except for scientific and educational purposes	intertidal	Y	Y	Y	N	Y	Y	Y	Y	Y		Y	Y	Y	Y	Y
	Whale Cove Habitat Reguse	ODFW	1960s	OR		Yes	Closed to the commercial and recreational take of marine fish, shellfish and invertebrates		No	subtidal	N	N	N	N	N	N	N	N	N		N	N	N	N	N
	Rogue River Commercial Fishing Closure Area	ODFW		OR		No	Closed to all commercial fishing for food fish except for shellfish				N	N	N	Y	N	N	Y	Y	Y		N	N	N	N	Y
	Curry County Rivers Commercial Fishing Closure Areas	ODFW		OR		No	Closed to all commercial fishing for food fish	includes Floras creek, Hunters Creek, Sixes River, Pistol River, Elk River, Chetco River, Euchre Creek, Winchuck Creek			N	N	N	N	N	N	Y	Y	Y		N	N	N	N	Y
	Umpqua River Commercial Fishing Closure Area	ODFW		OR		No	Closed to all commercial fishing for sturgeon				Y	Y	Y	Y	Y	Y	Y	Y	Y		Y	Y	Y	Y	Y
	Nestucca Bay Commercial Fishing Closure Area	ODFW		OR		No	Closed to all commercial fishing for food fish except for shellfish				N	N	N	Y	N	N	Y	Y	Y		N	N	N	N	Y
	Willametter River and tributaries Commercial Fishing Closure Area	ODFW		OR		No	Closed to commercial take of salmon, shad, striped bass or sturgeon				Y	N	Y	Y	Y	Y	Y	Y	Y		Y	Y	Y	Y	Y
	Columbia River Tributaries Commercial Fishing Closure Area	ODFW		OR		No	Closed to all commercial fishing for food fish	relates to all tributaries of the Columbia River. Commercial fishing is also restricted in santuary waters designated in OAR 635-042-0005 and OAR 041-0045.			N	N	N	N	N	N	Y	Y	Y		N	N	N	N	Y
California																									

SITE_ID	FULLNAME	AGENCY	YEAR ESTABLISHED	STATE	GIS layer updated?	Is this area closed to all fishing by regulations specific to the site?	Fishing Regulations **specific to the site's designation**	OTHER FISHING RELATED NOTES (R = recreational fishing, C = commercial fishing)	KELP or seaweed harvest restricted by rules specific to site?	OTHER INFORMATION	Is TRAWL gear allowed? (bottom, mid-water, shrimp, beam trawls)	Are other NETS allowed? (seine, gillnet, salmon reefnet, demersal seine)	Is DREDGE gear allowed?	Is commercial POT gear allowed?	Is commercial HOOK & LINE gear allowed?	Is OTHER commercial fishing gear allowed?	Is recreational HOOK & LINE gear allowed?	Is recreational POT gear allowed?	Are OTHER recrea-tional fishing gears allowed?		Is Groundfish Bottom Trawl gear allowed?	Is Groundfish Longline gear allowed?	Is Groundfish pot gear allowed?	Is Groundfish mid-water TRAWL gear allowed?	Is recrea-tional Groundfish gear allowed?
	CINMS Anacapa Island State Marine Reserve	CDFG	Oct-02	CA		Yes	no commercial or recreational fishing allowed	Shoreline length 3.3 nm, Area 1.7 square nm, Depth Range 0-600 feet (0-100 fathoms)	Yes	In 1978 Anacapa Island designated as Ecological Reserve; Fishing regs under that designation: recreational and commercial fishing allowed, but nothing allowed to be taken in Natural Area on north side of East Anacapa Island (extending out to 60 feet (10 fathoms) ; no invertebrates taken in closures on S. side of West Anacapa Island (extending out to 20 feet depth), on north side of Middle Anacapa Island (extending out to 20 feet depth). No net or trap used in waters less than 20 feet depth. No entry to closed area on N. side of West Anacapa Island Jan1-October 31	N	N	N	N	N	N	N	N	N		N	N	N	N	N
	CINMS Santa Barbara Island State Marine Reserve	CDFG	Oct-02	CA		Yes	no commercial or recreational fishing allowed	Shoreline length 1 nm, Area 13. square nm, Depth Range 0-1,800 feet (O-300 fathoms)	Recreational harvest of kelp prohibited; commercial harvest in kelp lease sites permitted.	In 1978 Santa Barbara Island designated as Ecological Reserve; Fishing regs under that designation: recreational and commercial fishing allowed, but no invertebrates taken in special closure area on eastern side of island (to 20 feet depth) and no net or traps allowed to be used in this area.	N	N	N	N	N	N	N	N	N		N	N	N	N	N
	CINMS Carrington Point (Santa Rosa Island) State Marine Reserve	CDFG	Oct-02	CA		Yes	no commercial or recreational fishing allowed	Shoreline length 5.3 nm, Area 13.3 square nm, Depth range 0-180 feet (0-30 fathoms)	Yes		N	N	N	N	N	N	N	N	N		N	N	N	N	N
	CINMS South Point (Santa Rosa Island) State Marine Reserve	CDFG	Oct-02	CA		Yes	no commercial or recreational fishing allowed	Shoreline length 3.8 nm, Area 10.8 square nm, Depth Range 0-1200 feet (0-200 fathoms)	Yes		N	N	N	N	N	N	N	N	N		N	N	N	N	N
	CINMS Gull Island (Santa Cruz Island) State Marine Reserve	CDFG	Oct-02	CA		Yes	no commercial or recreational fishing allowed	Shoreline length 2.9 nm, Area 16.1 square nm, Depth Range 0-1800 feet (0-300 fathoms)	Yes		N	N	N	N	N	N	N	N	N		N	N	N	N	N
	CINMS Scorpion (Santa Cruz Island) State Marine Reserve	CDFG	Oct-02	CA		Yes	no commercial or recreational fishing allowed	Shoreline length 3.3 nm, Area 10.3 square nm, Depth Range 0-750 feet (0-125 fathoms)	Yes		N	N	N	N	N	N	N	N	N		N	N	N	N	N
	CINMS Richardson Rock (San Miguel Island) State Marine Reserve	CDFG	Oct-02	CA		Yes	no commercial or recreational fishing allowed	Area 32.2 square nm, Depth range 0-360 feet (0-60 fathoms)	Yes		N	N	N	N	N	N	N	N	N		N	N	N	N	N
	CINMS Judith Rock (San Miguel Island) State Marine Reserve	CDFG	Oct-02	CA		Yes	no commercial or recreational fishing allowed	In 1977 San Miguel Island designated as Ecological Reserve; Fishing regs under that designation: no fishing from shore or areas closed to boating; Where open to boating: commercial fishing allowed under permit for abalone, lobster, or sea urchin, or using hook and line or traps for rock crab; recreational fishing with hook and line, spear gun or hand held implements permitted	Yes	Shoreline length 1.4 nm, Area 5.1 square nm, Depth range 0-420 feet (0-70 fathoms)	N	N	N	N	N	N	N	N	N		N	N	N	N	N
	CINMS Harris Point (San Miguel Island) State Marine Reserve	CDFG		CA		Yes	no commercial or recreational fishing allowed (except within Cuyler harbor)		Yes	Shoreline length 6.3 nm, Area 18.2 square nm, Depth Range 0-300 feet (0-50 fathoms)	N	N	N	N	N	N	N	N	N		N	N	N	N	N
	CINMS Skunk Point (Santa Rosa Island) State Marine Reserve	CDFG		CA		Yes	no commercial or recreational fishing allowed		Yes	Shoreline length 2.7 nm, Area 1.4 square nm, Depth range 0-60 feet (0-10 fathoms)	N	N	N	N	N	N	N	N	N		N	N	N	N	N
	CINMS Anacapa Island State Marine Conservation Area	CDFG		CA		No	No take of living or non-living marine resources allowed except recreational fishing for spiny lobster and pelagic finfish allowed; commercial fishing for spiny lobster allowed	Pelagic finfish are defined as northern anchovy, barraacudas, billfishes, dolphinfish, Pacific herring, jack mackerel, Pacific mackerel, salmon, Pacific sardine, blue shark, salmon shark, shortfin mako shark, thresher sharks, swordfish, tunas, and yellowtail.	Yes	Shoreline length 2.2 nm, Area 8.1 square nm, Depth range 0-600 feet (0-100 fathoms)	N	N	N	Y	N	N	Y	Y	Y		N	N	N	N	N
	CINMS Painted Cave (Santa Cruz Island) State Marine Conservation Area	CDFG		CA		No	No take of living or non-living marine resources allowed except recreational fishing for spiny lobster and pelagic finfish is allowed	Pelagic finfish are defined as northern anchovy, barraacudas, billfishes, dolphinfish, Pacific herring, jack mackerel, Pacific mackerel, salmon, Pacific sardine, blue shark, salmon shark, shortfin mako shark, thresher sharks, swordfish, tunas, and yellowtail.	Yes	Shoreline length 2 nm, Area 2.1 square nm, Depth range 0-300 feet	N	N	N	N	N	N	Y	Y	Y		N	N	N	N	N
	California Kelp Beds closed areas	CDFG		CA	yes	No	In areas designated as closed, kelp can not be harvested		Yes		Y	Y	Y	Y	Y	Y	Y	Y	Y		Y	Y	Y	Y	Y
	MacKerricher State Park	CDPR, CDFG, SLC	1970	CA		No	To 1000 feet offshore, finfish and these invertebrates may be taken: abalone, (RC), chiones (R), clams (R), cockles (R), rock scallops (R), native oysters (R), crabs (R,C), lobsters (R,C), ghost shrimp (R,C), sea urchins (R,C), jacknife clams (C), squid (C), worms (R,C).				Y	Y	N	Y	Y	Y	Y	Y	Y		Y	Y	Y	Y	Y
	Pt. Cabrillo Reserve	CDFG	1975	CA		No	Recreational fishing prohibited; Commercial fishing allowed for finfish and for the following invertebrates: lobster, abalone, and crab				Y	Y	N	Y	Y	Y	N	N	N		Y	Y	Y	Y	N
	Russian Gulch State Park	CDPR, CDFG, SLC	1970	CA		No	To 1000 feet offshore, finfish and these invertebrates may be taken: abalone, (RC), chiones (R), clams (R), cockles (R), rock scallops (R), native oysters (R), crabs (R,C), lobsters (R,C), ghost shrimp (R,C), sea urchins (R,C), jacknife clams (C), squid				Y	Y	N	Y	Y	Y	Y	Y	Y		Y	Y	Y	Y	Y
	Van Damme State Park	CDPR, CDFG, SLC	1970	CA		No	To 1000 feet offshore, finfish and these invertebrates may be taken: abalone, (RC), chiones (R), clams (R), cockles (R), rock scallops (R), native oysters (R), crabs (R,C), lobsters (R,C), ghost shrimp (R,C), sea urchins (R,C), jacknife clams (C), squid				Y	Y	N	Y	Y	Y	Y	Y	Y		Y	Y	Y	Y	Y
	Manchester State Park	CDPR, CDFG, SLC	1970	CA		No	To 1000 feet offshore, finfish and these invertebrates may be taken: abalone, (RC), chiones (R), clams (R), cockles (R), rock scallops (R), native oysters (R), crabs (R,C), lobsters (R,C), ghost shrimp (R,C), sea urchins (R,C), jacknife clams (C), squid				Y	Y	N	Y	Y	Y	Y	Y	Y		Y	Y	Y	Y	Y
	Arena Rock National Preserve	CDPR, CDFG, SLC	1987	CA		No	Access restrictions: No person shall drive, operate, place, land, taxi, takeoff, or stop a motor vehicle, motorboat or aircraft within the boundaries.			No fishing restrictions per say-- only access restrictions	N	N	N	N	N	N	N	N	N		N	N	N	N	N
	Del Mar Landing Ecological Reserve	CDFG	1972	CA		No	Recreational fishing allowed for finfish only; commercial fishing prohibited.			Do rec fishermen use pots for fnfish?	N	N	N	N	N	N	Y	N	Y		N	N	N	N	Y

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	Salt Point State Park	CDPR, CDFG, SLC	1970	CA		No	To 1000 feet offshore, finfish and these invertebrates may be taken: abalone, (RC), chiones (R), clams (R), cockles (R), rock scallops (R), native oysters (R), crabs (R,C), lobsters (R,C), ghost shrimp (R,C), sea urchins (R,C), jacknife clams (C), squid				Y	Y	N	Y	Y	Y	Y	Y	Y		Y	Y	Y	Y	Y
	Gerstle Cove Reserve	CWRCB, RWQCB, CDFG	1971	CA		No	Recreational fishing prohibited; Commercial fishing allowed for finfish and for the following invertebrates: lobster, abalone, and crab				Y	Y	N	Y	Y	Y	N	N	N		Y	Y	Y	Y	N
	Fort Ross State Historic Park	CDPR, CDFG, SLC	1970	CA		No	Commercial fishing allowed; To 1000 fish offshore, recreational fishing for finfish and the following invertebrates: abalone, chiones, clams, cockles, rock scallops, native oysters, crabs, lobsters, ghost shrimp, sea urchins				Y	Y	Y	Y	Y	Y	Y	Y	Y		Y	Y	Y	Y	Y
	Sonoma Coast State Beach	CDPR, CDFG, SLC	1970	CA		No	Commercial fishing allowed; To 1000 fish offshore, recreational fishing for finfish and the following invertebrates: abalone, chiones, clams, cockles, rock scallops, native oysters, crabs, lobsters, ghost shrimp, sea urchins				Y	Y	Y	Y	Y	Y	Y	Y	Y		Y	Y	Y	Y	Y
	Bodega Marine Life Refuge	CWRCB, RWQCB, CDFG	2002	CA		Yes	No-take marine reserve			Established 1965 and allowed recreational and commercial fishing only for finfish, until no-take reserve established	N	N	N	N	N	N	N	N	N		N	N	N	N	N
	Pt. Reyes Headlands Reserve	CDFG	1972	CA		No	Recreational fishing prohibited; Commercial fishing allowed for finfish and for the following invertebrates: lobster, abalone, and crab				Y	Y	N	Y	Y	Y	N	N	N		Y	Y	Y	Y	N
	Duxbury Reef Reserve	CDFG	1971	CA		No	Commercial fishing allowed; Recreational fishing only for: abalone, Dungeness crab, rock crab, rickfish, lingcod, cabezon, surfperch, haliput, flounder, sole, turbot, salmon, kelp greenling, striped bass, steelhead, monkey faced eel, wolf-eel, smelt, silversides.				Y	Y	Y	Y	Y	Y	Y	Y	Y		Y	Y	Y	Y	Y
	James V. Fitzgerald Marine Reserve	CDFG		CA		No	Recreational fishing only for abalone, rockfish, lingcod, surfpearch, monkey-faced eel, rock eel, white croaker, halibut, cabezon, kelp greening, and smelt. Finfish taken only by hook and line or spearfishing. Commercial fishing only by holders of species--specific CDFG permits; To 1000 feet offshore, only the following invertebrates may be taken: lobster, abalone, crab. Abalone may be taken in waters 20 feet or more in depth.			Do rec fishermen use pots for these species in CA?	N	N	N	Y	N	N	Y	N	Y		N	N	N	N	Y
	Hopkins Marine Life Reserve	CDFG	1984	CA		Yes	Recreational and commercial fishing prohibited				N	N	N	N	N	N	N	N	N		N	N	N	N	N
	Pacific Grove Marine Gardens Fish Refuge	CDFG	1984	CA		No	Recreational fishing allowed, but mollusks and crustaceans may not be taken; Commercial fishing allowed, but only sardines, mackerel, anchovies, squid and herring may be taken by ring net, lampara net, or bait net.				N	Y	N	N	N	N	Y	N	Y		N	N	N	N	Y
	Carmel Bay Ecological Reserve	CDFG	1976	CA		No	Recreational fishing allowed for finfish only; commercial fishing prohibited.				N	N	N	N	N	N	Y	N	Y		N	N	N	N	Y
	Point Lobos Ecological Reserve	CDFG		CA		Yes	Recreational and commercial fishing prohibited				N	N	N	N	N	N	N	N	N		N	N	N	N	N
	Point Lobos Reserve	CDFG, CDPR	1973	CA		Yes	no take reserve			Regulations in place before the area received additional protection in XXXX were: 1000 feet offshore, finfish and these invertebrates may be taken: abalone, (RC), chiones (R), clams (R), cockles (R), rock scallops (R), native oysters (R), crabs (R,C), lobsters (R,C), ghost shrimp (R,C), sea urchins (R,C), jacknife clams (C), squid (C), worms (R,C)	N	N	N	N	N	N	N	N	N		N	N	N	N	N
	Julia Pfeiffer Burns State Park	CDPR, CDFG, SLC		CA		No	To 1000 feet offshore, finfish and these invertebrates may be taken: abalone, (RC), chiones (R), clams (R), cockles (R), rock scallops (R), native oysters (R), crabs (R,C), lobsters (R,C), ghost shrimp (R,C), sea urchins (R,C), jacknife clams (C), squid (C), worms (R,C).				Y	Y	N	Y	Y	Y	Y	Y	Y		Y	Y	Y	Y	Y
	Big Creek MRPA Ecological Reserve	CDFG	1994	CA		Yes	Recreational and commercial fishing prohibited				N	N	N	N	N	N	N	N	N		N	N	N	N	N
	Atascadero Beach Pismo Clam Preserve (Clam Refuge)	CDFG	1985	CA		No	No clams may be taken				Y	Y	Y	Y	Y	Y	Y	Y	Y		Y	Y	Y	Y	Y
	Morro Beach Pismo Preserve (Clam Refuge)	CDFG	1985	CA		No	No clams may be taken				Y	Y	Y	Y	Y	Y	Y	Y	Y		Y	Y	Y	Y	Y
	Pismo Invertebrate Reserve	CDFG	1977	CA		No	Recreational fishing allowed only for finfish; Commercial fishing is allowed for finfish and the following shellfish: lobster, abalone, crab				Y	Y	N	Y	Y	Y	Y	N	N		Y	Y	Y	Y	Y
	Pismo-Oceano Beach Pismo Clam Preserve (Clam Refuge)	CDFG	1985	CA		No	No clams may be taken				Y	Y	Y	Y	Y	Y	Y	Y	Y		Y	Y	Y	Y	Y
	Vandenberg MRPA Ecological Reserve	CDFG, Vandenberg AFB	1994	CA		Yes	Recreational and commercial fishing prohibited				N	N	N	N	N	N	N	N	N		N	N	N	N	N
	San Miguel Island Ecological Reserve	CDFG	1977	CA		No	Recreational fishing by hook-and-line, spear gun, or hand-held implements in areas open to boating; Commercial fishing under permit for abalone, lobster or sea urchin, or using hook-and-line or traps for rock crab, only in areas open to boating. Other gear/species fishermen must apply for and obtain permit				N	N	N	Y	Y	N	Y	N	Y		N	N	N	N	Y
	Anacapa Island Ecological Reserve Natural Area	CDFG	1978	CA		Yes	No-take reserve				N	N	N	N	N	N	N	N	N		N	N	N	N	N
	Santa Barbara Island Ecological Reserve	CDFG	1978	CA		No	No invertebrates taken in special closure on eastern side of island, and no net or trap used in that area.				N	N	N	N	Y	Y	Y	N	Y		N	N	N	N	Y
	Sycamore Canyon MRPA Ecological Reserve	CDFG	1994	CA		Yes	No-take reserve				N	N	N	N	N	N	N	N	N		N	N	N	N	N
	Abalone Cove Ecological Reserve	CDFG	1977	CA		No	Recreational fishing for finfish only; commercial fishing prohibited			Do rec fishermen use pots for groundfish in CA?	N	N	N	N	N	N	Y	N	Y		N	N	N	N	Y
	Point Fermin Marine Life Refuge	CDFG	1969	CA		No	Recreational fishing only for abalone, lobster, rockfish, greenling, lingcod, cabezon, yellowtail, mackerel, bluefin tuna, kelp bass, spotted sand bass barred sand bass, sargo, croaker, queenfish, corbina, white seabass, opaleye, halfmoon, surfperch, blacksmith, barracuda, sheephead, bonito, CA halibut, sole, turbot, and sanddab. Finfish taken only by hook-and-line or spearfishing. Commercial fishing only by holders of species-specific CDFG permits; To 1000 feet offshore, only the following invertebrates may be taken: lobster, abalone, crab.				N	N	N	Y	N	Y	Y	Y	Y		N	N	N	N	Y

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	Santa Catalina Island Marine Life Refuge	CDFG	1988	CA		Yes	No-take reserve				N	N	N	N	N	N	N	N	N		N	N	N	N	N
	Farnsworth Bank Ecological Reserve	CDFG	1972	CA		No	No purple coral or geological specimens may be taken				Y	Y	Y	Y	Y	Y	Y	Y	Y		Y	Y	Y	Y	Y
	Lovers Cover Reserve	CDFG	1974	CA		No	Recreational fishing prohibited; Commercial fishing allowed for finfish and for the following invertebrates: lobster, abalone, and crab				Y	Y	N	Y	Y	Y	N	N	N		Y	Y	N	Y	N
	Newport Beach Marine Life Refuge	CDFG	1981	CA		No	Recreational fishing only for abalone, lobster, rockfish, greenling, lingcod, cabezon, yellowtail, mackerel, bluefin tuna, kelp bass, spotted sand bass barred sand bass, sargo, croaker, queenfish, corbina, white seabass, opaleye, halfmoon, surfperch, blacksmith, barracuda, sheephead, bonito, CA halibut, sole, utrbot, and sanddab. Fishfish taken only by hook-and-line or spearfishing. Commercial fishing only by holders of species-specific CDFG permits: To 1000 feet offshore, only the following invertebrates may be taken: lobster, abalone, crab.				N	N	N	Y	N	Y	Y	Y	Y		N	N	N	N	Y
	Crystal Cove State Park	CDPR, CDFG, SLC	1982	CA		No	To 1000 feet offshore, finfish and these invertebrates may be taken: abalone, (RC), chiones (R), clams (R), cockles (R), rock scallops (R), native oysters (R), crabs (R,C), lobsters (R,C), ghost shrimp (R,C), sea urchins (R,C), jacknife clams (C), squid				Y	Y	N	Y	Y	Y	Y	Y	Y			Y	Y	Y	Y
	Irvine Coast Marine Life Refuge	CDFG	1971	CA		No	Recreational fishing only for abalone, lobster, rockfish, greenling, lingcod, cabezon, yellowtail, mackerel, bluefin tuna, kelp bass, spotted sand bass barred sand bass, sargo, croaker, queenfish, corbina, white seabass, opaleye, halfmoon, surfperch, blacksmith, barracuda, sheephead, bonito, Ca halibut, sole, turbot, and sanddab. Finfish taken ony by hook-and-line or spearfishing. Commercial fishing only by holders of species-specific CDFG permits; To 1000 feet offshore only the following invertebrates may be taken: lobster, abalone, crab.				N	N	N	Y	N	Y	Y	Y	Y		N	N	N	N	Y
	Laguna Beach Marine Life Refuge	CDFG	1968	CA		No	Recreational fishing only for abalone, lobster, rockfish, greenling, lingcod, cabezon, yellowtail, mackerel, bluefin tuna, kelp bass, spotted sand bass barred sand bass, sargo, croaker, queenfish, corbina, white seabass, opaleye, halfmoon, surfperch, blacksmith, barracuda, sheephead, bonito, Ca halibut, sole, turbot, and sanddab. Finfish taken ony by hook-and-line or spearfishing. Commercial fishing only by holders of species-specific CDFG permits; To 1000 feet offshore only the following invertebrates may be taken: lobster, abalone, crab.				N	N	N	Y	N	Y	Y	Y	Y		N	N	N	N	Y
	Heisler Park Ecological Reserve	CDFG	1973	CA		Yes	No-take reserve				N	N	N	N	N	N	N	N	N		N	N	N	N	N
	South Laguna Beach Marine Life Refuge	CDFG	1968	CA		No	Recreational fishing only for abalone, lobster, rockfish, greenling, lingcod, cabezon, yellowtail, mackerel, bluefin tuna, kelp bass, spotted sand bass barred sand bass, sargo, croaker, queenfish, corbina, white seabass, opaleye, halfmoon, surfperch, blacksmith, barracuda, sheephead, bonito, Ca halibut, sole, turbot, and sanddab. Finfish taken ony by hook-and-line or spearfishing. Commercial fishing only by holders of species-specific CDFG permits; To 1000 feet offshore only the following invertebrates may be taken: lobster, abalone, crab.				N	N	N	Y	N	Y	Y	Y	Y		N	N	N	N	Y
	Niguel Marine Life Refuge	CDFG	1971	CA		No	Recreational fishing only for abalone, lobster, rockfish, greenling, lingcod, cabezon, yellowtail, mackerel, bluefin tuna, kelp bass, spotted sand bass barred sand bass, sargo, croaker, queenfish, corbina, white seabass, opaleye, halfmoon, surfperch, blacksmith, barracuda, sheephead, bonito, Ca halibut, sole, turbot, and sanddab. Finfish taken ony by hook-and-line or spearfishing. Commercial fishing only by holders of species-specific CDFG permits; To 1000 feet offshore only the following invertebrates may be taken: lobster, abalone, crab.				N	N	N	Y	N	Y	Y	Y	Y		N	N	N	N	Y
	Dana Point Marine Life Refuge	CDFG	1969	CA		No	Recreational fishing only for abalone, lobster, rockfish, greenling, lingcod, cabezon, yellowtail, mackerel, bluefin tuna, kelp bass, spotted sand bass barred sand bass, sargo, croaker, queenfish, corbina, white seabass, opaleye, halfmoon, surfperch, blacksmith, barracuda, sheephead, bonito, Ca halibut, sole, turbot, and sanddab. Finfish taken ony by hook-and-line or spearfishing. Commercial fishing only by holders of species-specific CDFG permits; To 1000 feet offshore only the following invertebrates may be taken: lobster, abalone, crab. No species may be taken in the intertidal zone.				N	N	N	Y	N	Y	Y	Y	Y		N	N	N	N	Y
	Doheny State Beach	CDFG	1969	CA		No	Recreational fishing only for abalone, lobster, rockfish, greenling, lingcod, cabezon, yellowtail, mackerel, bluefin tuna, kelp bass, spotted sand bass barred sand bass, sargo, croaker, queenfish, corbina, white seabass, opaleye, halfmoon, surfperch, blacksmith, barracuda, sheephead, bonito, Ca halibut, sole, turbot, and sanddab. Finfish taken ony by hook-and-line or spearfishing. Commercial fishing only by holders of species-specific CDFG permits; To 1000 feet offshore only the following invertebrates may be taken: lobster, abalone, crab.				N	N	N	Y	N	Y	Y	Y	Y		N	N	N	N	Y

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	City of Encinitas Marine Lif Refuge	CDFG	1989	CA		No	Recreational fishing only for abalone, lobster, rockfish, greenling, lingcod, cabezon, yellowtail, mackerel, bluefin tuna, kelp bass, spotted sand bass barred sand bass, sargo, croaker, queenfish, corbina, white seabass, opaleye, halfmoon, surfperch, blacksmith, barracuda, sheephead, bonito, Ca halibut, sole, turbot, and sanddab. Finfish taken ony by hook-and-line or spearfishing. Commercial fishing only by holders of species-specific CDFG permits; To 1000 feet offshore only the following invertebrates may be taken: lobster, abalone, crab.				N	N	N	Y	N	Y	Y	Y	Y		N	N	N	N	Y
	Cardiff and Elijo State Beaches	CDPR, CDFG, SLC	1989	CA		No	Commercial fishing allowed; To 1000 feet offshore, recreational fishing for finfish and the following invertebrates allowed: abalone, chiones, clams, cockles, rock scallops, native oysters, crabs, lobsters, ghost shrimp, sea urchins				Y	Y	Y	Y	Y	Y	Y	Y	Y		Y	Y	Y	Y	Y
	San Diego Marine Life Refuge	CDFG		CA		No	Recreational and commercial fishing allowed only fo finfish			Do rec and commercial fishermen use pots for groundfish in CA?	Y	Y	Y	Y	Y	Y	Y	Y	Y		Y	Y	Y	Y	Y
	U.C. Scripps Natural Reserve	UC;CDFG	1965	CA		Yes	Recreational and commercial fishing prohibited				N	N	N	N	N	N	N	N	N		N	N	N	N	N
	San Diego-La Jolla Ecological Reserve	CDFG	1971	CA		No	Recreational fishing prohibited; Commercial fishing allowed only for bait squid using a hand-held scoop net.				N	N	N	N	N	Y	N	N	N		N	N	N	N	N
	Point Loma Reserve	CDFG, NPS	1978	CA		No	Recreational fishing for finfish only; commercial fishing for finfish, with restrictions on invertebrates. To 1000 feet offshore, only the following invertebrate may be taken commercially: lobster, abalone, crab.				Y	Y	Y	Y	Y	Y	Y	N	Y		Y	Y	Y	Y	Y
	Kings Range MRPA Ecological Reserve	CDFG	1994	CA		Yes	No-take reserve				N	N	N	N	N	N	N	N	N		N	N	N	N	N